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Becoming a Scientist

David Starr Jordan (B. 1851 - D. 1931)

• **By Otis W. Caldwell, Ph.D.** *(University of Chicago)*
GENERAL SECRETARY, AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, YONKERS, N. Y.

This inspiring little story of an obscure farm boy who became a world-famous scientist and educator is designed to interest students in making library studies and reports of the achievements of great men in science.

In succeeding numbers we hope to have Dr. Caldwell present several other "Becoming a Scientist" articles. Like this paper, they will not discuss in detail what the scientist did. That is for the student to discover.

If a high school pupil prepares a report on David Starr Jordan which the teacher considers worthy of publication it may be submitted to the Editor before June 1. The single best paper of those received will appear in our September issue.

●

David Starr Jordan was known as a "queer" boy. His parents had the old-fashioned names, Hiram and Huldah. The boy's home in rural New York was "commonplace," as people now think of homes. When he was seven years of age, his older brother asked him to help lead the horses from the barn, and when the younger boy failed to manage the horses properly he was the object of his brother's remark, "That boy never will have any sense." The records have not told us anything more about the older brother. If David could not lead a horse properly he could do many other things. At that age he could read anything available. Indeed, when later he became a famous university president, he said he could not remember when he could not read, but could remember sitting on his mother's lap, picking out words as she read the weekly newspaper.

Young Jordan gave himself his middle name, Starr, because of his early interest in astronomy, and because both he and his mother admired a writer whose middle name was Starr (Thomas Starr King). Indeed, his mother observed the constellations with the young boy, discussed them, hunted good reading about stars, trees, insects and other animals, about mountains, and water flowing down hill, and about many other common things. The boy's tentacles of inquiry reached in all directions, and his mother helped him to learn about things to satisfy his unusually active curiosity. If he couldn't learn the answers, he learned why he couldn't find out. In many cases he laid away a question to return to it later. By his thirteenth birthday he knew more than is known by the average adult about common plants and animals, and about planets, stars, constellations, astronomical distances and magnitudes. Teaching mothers are quite too rare. It seems certain that there was close relationship between the boy's interests and capacities to learn and the mother's qualities which made her his great childhood teacher.

Later, young Jordan tramped the fields and woods with an old man whom the neighbors regarded as shiftless because he used so much time in learning to know all the native plants of his region. The boy's avid mind caught and retained much nature knowledge. When, in 1869, he entered Cornell University he knew enough about plant life that he could earn his college expenses by assisting in teaching. In later life he once said that he had seventy-five dollars when he entered college and had seventy-five dollars when he was graduated from college. He had held his own financially, paid all of his expenses, and his learning and ambition had grown immensely. Meantime his achievements in athletics would have given him great prominence in our later day. But he was best known for two things: his budding authority in several sciences; and his unusual effectiveness as a teacher. He was tremendously interested in learning new things, and equally interested in how things appear to those in process of learning about them. These two things help to make great teachers.

Under Agassiz as a teacher, Jordan grew amazingly so that Agassiz recommended him in extreme language. Good positions came to him and he used them for further education for himself and for all with whom he was associated. He studied medicine, becoming an M. D. so that he might teach physiology in a better way. He went wherever birds, fish, and paleontological materials were being studied so that his own knowledge might be supplemented and checked. He spoke and wrote unusually effectively about a wide range of scientific tops. He was peculiarly successful as a college and university administrator. His intelligence and frankness relieved him of dependence on extensive files of what he had said, because he always spoke the truth as the facts seemed to justify. His friends were almost as extensive as his large acquaintance.

It is not the purpose of this brief statement to present details of any particular one of Dr. Jordan's many highly important studies nor to recount the achievements of the great educational institutions over which he presided. He was the author of many research publications and of books designed to make biology useful to others. Any good library should help those interested

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Behold the Birds of the Air

• **By Edith Portman**
SECRETARY, AUDUBON SOCIETY OF WESTERN PENNSYLVANIA, MELLON INSTITUTE, PITTSBURGH, PA.

Bird study is a fascinating pastime. It can be practiced anywhere, any time. It requires little or no equipment.

Attracted at first by its entertainment value alone the bird watcher may later become seriously interested in the conservation and protection of birds, and a student of their biology and their economic and esthetic importance.

Miss Portman's paper should stimulate teachers of biology to consider the formation of bird clubs for children and adults, the arranging of bird walks, and other activities that will stimulate the admiration, enjoyment, and intelligent study of "the birds of the air".

●

Ever since the early days of creation "when birds were born the first of things", these winged creatures have obeyed the natural law and filled the earth with life and color. True it is that the encroachment of civilization has depleted their ranks by indiscriminate drainage of swamps and the needless destruction of the vegetation that afforded food and shelter. Man himself has exterminated some species and their natural enemies have taken heavy toll. All in all, it is estimated that only ten per cent of the nestlings survive each year. Still with every returning spring, the birds again fill northern fields and woods with song. Annually they resume a relentless war against the insect foes of man, thus playing their role in preserving the balance of nature.

From the earliest times, the ways of a bird have been an absorbing subject of study not only to a long line of ornithologists but also to men and women in many fields of endeavor. Often, as in the case of Theodore Roosevelt, interest in birdlore may begin in boyhood and continue throughout a lifetime.

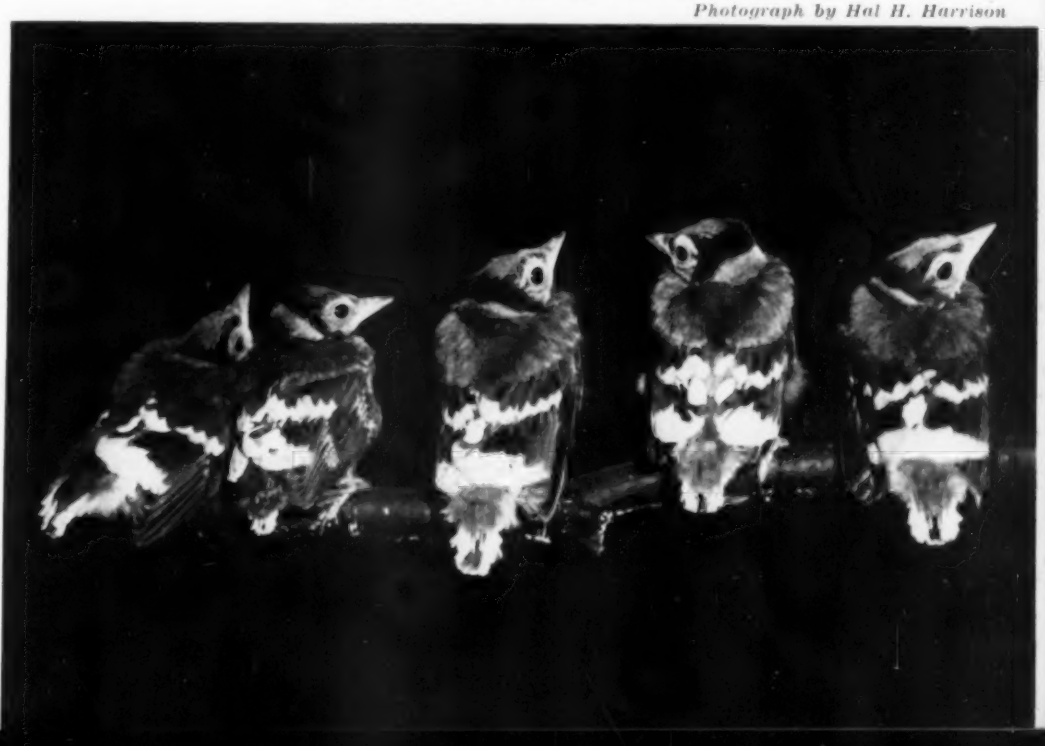
Few hobbies are as fascinating as the observation and study of the living bird, and few subjects have such a varied appeal. Biology students may be amazed at the perfection of a bird's wing or the bone structure that adapts it to flight, but this coldly intellectual approach cannot be compared to the thrill of the outdoor watcher when he first glimpses a scarlet tanager in full song or marvels at the architectural skill of an oriole.

Bird study has as many facets as a diamond. Beginning as entertainment, it leads the watcher on to more serious study and to a keener appreciation of the mysteries of bird life. Then follows that mark of good citizenship, a realization of the importance of conservation and the desire to protect the wild birds which have become fast friends.

To some, observation of the family life of birds is intriguing; to others their photography in color and motion is a challenge and a delight. A challenge because it involves unlimited time and patience. A delight because of the amazing results. The kodachrome slide provides as accurate a record as would the bird in the hand, while motion pictures can go even further and portray the life at the nest.

Awareness of bird song opens a whole new world of happiness to an ear attuned to nuances of tone. To many this mode of identification is the most satisfying. It is surprising how easily even the casual observer can learn to distinguish the songs of the more common birds —to recognize and enjoy the vesper song of the wood thrush or the vocal exhibition of a catbird.

But as though the pleasure derived from bird watching were not enough, there is added the sense of physical



YOUNG BLUE JAYS POSE FOR THE PHOTOGRAPHER.
Photograph by Hal H. Harrison

well-being which accompanies any outdoor pursuit. There is a quickened perception of every sight and sound, and the ability to observe quickly and accurately.

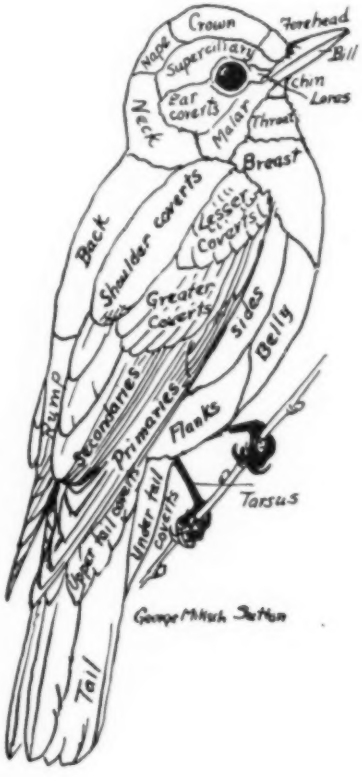
The countryside and the life found there have a special appeal to young people. One field trip under the guidance of an experienced leader is worth more in spiritual and lasting value than many hours in the classroom. But because so few students can have the opportunity for first-hand information, the National Audubon Society sponsors bird clubs in the elementary schools. Each member receives descriptive booklets for either junior or senior grades, colored pictures of birds and outlines for coloring, while the teacher receives a bi-monthly news sheet.

Local bird clubs also stand ready to assist the schools in every way possible. For instance, the Audubon Society of Western Pennsylvania maintains an excellent kodaslide library on birds and other nature subjects. These slides are shown in the schools of Pittsburgh and vicinity without charge. In addition, the individual members frequently give illustrated lectures. Last year the president, C. B. Shoemaker, showed colored motion pictures to 89 school groups, bringing the story of the birds and the message of conservation to more than 16,000 children. Unfortunately, few parochial schools have taken advantage of this service, although they would be among the first to acknowledge the value of nature study in character building. An associate membership in the local Audubon Society is extended to high school students and college undergraduates. The Society also publishes a "Field List of Birds of Western Pennsylvania" which provides a checklist and gives suggestions for bird study that are helpful to beginners.

Birds are active and elusive, and their identification is a test of the patience and keenness of the observer. The identification of different species is a pastime that may be followed singly or with as many as care to take part. Although a leader who knows the habitat of the different birds and who can give aid by description or by references to the illustrations in a bird book is not an absolute necessity, he does much to make bird walks pleasant and profitable. However, all that are really needed are binoculars, a pencil and notebook, and a good bird guide with colored illustrations. In fact, better work can be done alone or in small groups. An exact record is kept of the place and date each species is seen, with a note of any unusual circumstances. More careful observers also note the weather, the time of day, and the number of each species seen. The aim is to identify as many species as in the previous year.

Early morning, or from four o'clock until dusk are the best times for field study as most birds are more active then. Walk quietly and slowly along the trails if you would see the creatures of the wild. Birds have excellent eyesight and hearing; so quick movements and loud noises always startle them. It is not necessary to walk long distances to find birds. Sometimes more real enjoyment is found by remaining quietly in some suitable bird territory and letting them come to you.

Beginners should learn first to observe and describe a bird accurately, by using designations such as are given in the accompanying outline. With the help of a good bird book, learn the destinctive field marks of the common birds, those special markings that distinguish one species from all others. For comparative size, keep in mind a few standard lengths, such as the sparrow, robin, and crow, then use these as a measure to determine the rarer kinds. It is well to remember that the plumage of some birds differs with the seasons, that the male and female may not look alike, and that the immature bird may not look like either parent. Puzzling it is true, but that is what makes bird study exciting.



To learn the songs and calls of birds is of much value. If after you have located an unfamiliar songster, you listen to the song again and again, memorizing the rhythm that resembles words, you have not only acquired an aid but have discovered a new source of enjoyment.

In all field trips there are two rules that should never be broken: Do not disturb the nests; do not unnecessarily walk up to a nest a second time. To do so marks the way for predators from whom the parent birds have cleverly concealed their young. The bird watcher admires and enjoys but never destroys the works of nature.

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Functional Competence in Mathematics

• **By William Betz.** Rochester, New York

Don't miss this important article.

Teachers of science often criticize the preliminary mathematical training of college students. So do some of the mathematicians who teach them.

The writer of this article, well known as a teacher, author, and lecturer, has had extensive experience in the field of curriculum research and of experimental teaching in laboratory schools. He has been President of the National Council of Teachers of Mathematics and a member of the Board of Governors of the Mathematical Association of America. Recently he has participated in the work of the Commission on Post-War Plans in Mathematics.

Mr. Betz doesn't mince words either in this article or in the concluding article, "Elements of a Functional Program in Mathematics," which will appear in our June number.

●

Introduction

A Scene of Conflict. For many years the status of elementary and secondary mathematics has been a highly controversial subject. During the recent war there was a temporary lull in this perennial debate. For did not the Army and the Navy absolutely insist on basic training in the fundamentals of mathematics? Vast sums of money were spent on creating dependable mathematical foundations, so conspicuously absent at the outset, which were deemed imperatively necessary in the all-consuming enterprise of national defense. The impressive story of what mathematics and science did to win the war has not yet been written. But now that we are returning to a peace basis, the old quarrel is being resumed with the usual fervor. As one educator expressed it, in the case of mathematics the war was merely "a shot in the arm."

The fundamental thesis of the educator is to the effect that "academic" mathematics of the usual type is largely "non-functional," and that it does not "meet the needs" of the vast majority of our young people. In the language of Dr. Cornelius H. Siemens, the director of Compton Junior College,

> "Anyone who looks at the mathematics program as offered by the typical high school finds a very close resemblance to the offerings of a century ago. It is a sober fact that we have made but minor changes in the total program of mathematics, whereas our school population has undergone a wholesale revolution, not to mention the social, economic, and technological changes in the world about us.
>
> "Without question the mathematics 'sequence' serves a very worthwhile purpose for a selected group of students who will continue their education particularly in mathematics, science, and engineering. However, the other 85% have an altogether different set of needs and interests in mathematics. The schools specifically, and society generally can be indicted with the charge that very little has been done to make mathematics palatable, interesting or worthwhile to the majority of our secondary school population.
>
> "It is becoming more evident that *a solution to this problem lies in a totally new program of mathematics for the non-college student*,* and perhaps even for a portion of the college bound students. *Instead of drawing from the organized body of the science of mathematics, the new program should result from an analysis of the life situations and experiences that students will likely have during and after their school training.* The results of such an analysis must then be organized into courses (required by mass education) and fitted into the core and elective portions of the curriculum."[1]

To what extent does such a declaration offer a true picture of the situation? Is it not a gross misstatement that only "minor changes" are said to have occurred "in the total program of mathematics" in the course of a century? Can it be that this educator has never even heard of the National Council of Teachers of Mathematics and its continuous activity on behalf of mathematical reform? Has he ever examined its numerous yearbooks? Has he ever attended its meetings? And has he carefully compared an up-to-date text in junior-high-school mathematics, or in algebra, or in geometry, with corresponding texts of a generation ago? One wishes to know, also, what this critic has really found out about the "needs and interests" of "the other 85%". Again, how does he propose to ignore "the organized body of the science of mathematics" and to depend entirely on "an analysis of life situations and pupil experiences"?

Categorical and naive pronouncements of this sort nearly always involve large elements of error. In fact, it has long been obvious that neither side of the controversy has been presented with convincing clearness and with painstaking accuracy. As a rule, important factors are either disregarded or suppressed. And so, we usually get a decidedly oblique account. It is probably true that the average teacher of mathematics does not heed sufficiently the implications of mass education, has lost interest in the never-ending parade of miracle formulas, and often relies on archaic methods of instruction. On the other hand, the educator almost regularly overlooks or ridicules the *cumulative* character of mathematics. And yet, the sequential nature of mathematics is of its essence and cannot be abolished in favor of "life situations" without obtaining a type of "mathematics *without* mathematics."

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*Italics throughout by Mr. Betz.

Sharply contrasting with the preceding quotation, though also written by an educator, is a statment due to Dr. A. John Bartky, the new Dean of the School of Education at Stanford University. Under the heading "Guidance in Mathematics," he says:

"Guidance of secondary school mathematics students has degenerated into a simple procedure. If the student is failing, if his mathematical background is weak, or if he is not too much interested, the solution is stereotype: *Drop* all mathematics. How trivial all our problems would become if we followed the same pattern with other subjects! It would not be long before we would only have to concern ourselves with the upper seven to ten per cent of the student body. Teaching would become a sinecure and an amusement. . . .

"Mathematics teachers were just beginning to doubt Morrison when education was hit by the 'felt need and interest' advocates. Now it takes a pretty bright and alert child to create for himself a felt need or interest in high school mathematics. He does not know enough about it in the first place, and it requires considerable perserverance and work to get to the point where an interest is manifest in the second place. . . .

"By mathematics for all students is not meant that the objective shall be to make every high school pupil into an Einstein. But, we insist on reading for everyone although very few will read Aristotle, we ask that all write even though we do not expect millions of Sinclair Lewises to spring forth, and we teach general science knowing full well that not one in a thousand will discover an atomic bomb. *Mathematics is a definite part of living and culture.* We do not eat it, of course, nor does it help to make the student more aware of the 'inadequacies of our social order', but those facts alone do not constitute the sole function of education. *We have no right to deny any student the opportunity to see this side of human culture, nor dare we cut him loose from school without the necessary mathematical tools . . .*

"Of course, we can get along without a knowledge of high school mathematics. People can get along very well without being able to read also.

"But is 'getting along' the desirable thing? . . . Should we get back to a primitive state as rapidly as possible? *Our progress in all the sciences has to a large extent been dependent upon the use of the tool called 'mathematics.'* The algebraic formula is found in chemistry, physics, economics, psychology, social science, and education. The ordinary foreman in the inspection department of a large industrial concern is likely to meet problems in sampling involving theoretical probability. The atomic bomb was worked out mathematically as were thousands of less spectacular inventions. Is it not conceivable that the reason we ourselves do not employ more mathematics is mainly because most of us do not know any more? We were the group who could not master the subject, the ones who did not feel a need for it, were not interested in it and hence for the comfort of the teacher were 'guided' out of the mathematics classes.

"You counselors who advise students to discontinue their studies of mathematics, have you ever stopped to think how much you are limiting their future? The student who drops high school mathematics at the same time drops medicine, engineering, chemistry, biology, physics, economics, social science and psychology. He seriously handicaps himself if he plans on entering the teaching profession because teachers have to know these subjects and in addition are asked occasionally to do statistical work in the area of tests and measurements.

"The problem of guidance in mathematics is not just a matter of using a stop and go sign on the pupil. It is a highly complex process which must concern itself with the teacher as well as the pupil. The teacher must be taught that she has a responsibility to teach mathematics to all her students. She must feel the same way about mathematics as the elementary school teacher feels about reading. It has to be taught! . . . No secondary mathematics teacher should deign to take the responsibility of recommending 'no more mathematics' for any student.

"In guiding students in secondary mathematics the assumption must always be 'I shall assure myself that this student has every opportunity to learn as much mathematics as possible'."(2)

Perhaps these two divergent quotations suffice to characterize the impasse in which we find ourselves today. They also suggest both the difficulty and the necessity of formulating a generally-acceptable definition of "functional competence in mathematics." Once again, we are facing the age-long feud between theory and practice, made more acute than ever by the unresolved conflict between reckless individualism and social efficiency.

I. Educational Backgrounds

The Battle of Objectives. Ever since the arrival of the curriculum-revision movement, on a national scale, a veritable cataract of new courses of study has been poured out upon the schools. Every town and hamlet has felt the urge to issue its own particular brand of an "up-to-date" and streamlined program. In this enterprise, countless slogans, objectives, guiding principles, criteria of evaluation, "approaches," and "philosophies" have gone through a vast number of combinations and permutations. Moreover, this enormous output has been accompanied by a whole library of curriculum treatises, committee reports and yearbooks, not to mention endless lecture courses and thousands of related articles in professional and popular journals. In one single "curriculum laboratory" more than 85,000 courses of study have been assembled, nearly 9000 of them in mathematics alone. And the end is not yet.

There are competent judges who have characterized this game as utterly silly, indicative of educational chaos and menacing our cultural solidarity. It is certainly true that the confusion of our educational objectives has become a source of hopeless bewilderment to our teachers, administrators and guidance counselors. This view is shared by none other than Professor Dewey himself, the man who is so largely responsible for our outlook in education and our educational policies. In a comparatively recent magazine article he said, "*We agree that we are uncertain as to where we are going*

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Tyrothricin

• By C. P. Hegarty, Ph.D. *(Cornell University)*
MEDICAL RESEARCH DIVISION, SHARP & DOHME, INC., GLENOLDEN, PENNSYLVANIA

The public press has given much attention to the "wonder drugs" penicillin and streptomycin. Less has been published about a third antibiotic, tyrothricin, because less has been known.

Like the others, tyrothricin is derived from a soil micro-organism. It is being used in increasing amounts by physicians and veterinarians to combat certain pathogenic gram-positive bacteria.

Here is an up-to-the-minute account of this valuable antibacterial agent written by an outstanding worker in the field.

●

For many years it has been common knowledge that the soil is the habitat of many micro-organisms, and that some of these organisms produce substances capable of inhibiting or preventing the growth of other bacteria that cause disease in man and animals. These bacteriostatic or bactericidal substances are called antibiotics. In the broad sense of the word, antibiotic means destructive to life, but it is applied more commonly to substances that bring about the destruction or inhibit the growth of pathogenic organisms.

The development of cultural technics for the isolation and study of soil bacteria, and of biochemical procedures for the identification and preparation of antibacterial substances from these bacteria, has resulted in the production of a number of antibiotic substances, among which is tyrothricin. It was in 1939 that Dr. Dubos first prepared the active antibacterial principle, tyrothricin, from cultures of an aerobic, spore-bearing, soil bacillus, which he later identified as *Bacillus brevis*. This is a motile bacillus, about 4 x 0.5 microns in dimension, with subterminal oval spores. When tyrothricin was tested against certain gram-positive bacteria, this substance was found capable of lyzing or destroying the bacterial cells, of inhibiting their growth, and of affecting their metabolism adversely. Not only did tyrothricin interfere with the growth of bacterial cultures in the test tube, it also protected laboratory animals like the mouse against disease when living, virulent cultures of a pathogenic organism such as, for example, the pneumococcus, were injected into the latter.

Tyrothricin is not a single entity but a combination of at least two active fractions, gramicidin and tyrocidine. On further purification and chemical analysis of this antibiotic it was found that the two fractions could be obtained in crystalline form, and tyrothricin was reported by various investigators to contain approximately 10 to 20 per cent of gramicidin and from about 40 to 80 per cent of tyrocidine. Gramicidin is by far the more active of the two pure principles, but tyrocidine is also active and possesses certain chemical and biologic properties that make it unnecessary to separate the two fractions for use in the treatment of disease. Tyrothricin is soluble in alcohol, but insoluble in water and body fluids. This interesting antibiotic is highly active against gram-positive micro-organisms such as pneumococci, streptococci, and staphylococci, and it is also moderately active against the meningococcus and gonococcus.

Since tyrothricin causes hemolysis of the red blood corpuscles, it must be considered as a surface-active material from the clinical point of view, and thus its use in medicine must be confined to topical application or instillation into cavities that have no direct communication with the blood stream. Tyrothricin apparently is ineffective when taken orally, and it cannot be injected because of its toxic effect when present in the blood stream. For medicinal purposes tyrothricin is applied locally in the form of a fine suspension in sterile distilled water, since it is insoluble in water and will not form a true solution. The concentrations usually employed are from 200 to 500 micrograms (0.2 to 0.5 milligram) per cubic centimeter.

In 1942, two Russian scientists, Gause and Brazhnikova, isolated an antibacterial agent known as Soviet gramicidin or gramicidin "S." This antibiotic is derived from another strain of *Bacillus brevis* than that of Dubos, and it differs also in some of its physical characteristics, such as solubility, and in its antibacterial activity. It is claimed that gramicidin "S" is effective against gram-negative as well as gram-positive organisms, whereas tyrothricin usually is not, although the tyrocidine component of tyrothricin attacks some gram-negative bacteria. According to the discoverers of gramicidin "S," it is four times more effective than tyrothricin against staphylococci, but tyrothricin has a greater effect on pneumococci and streptococci. Gramicidin "S" and tyrothricin appear to have about the same toxicity. Soviet gramicidin is employed clinically in a slightly higher concentration than is tyrothricin (400 to 800 micrograms of gramicidin "S" per cubic centimeter).

In evaluating the potential usefulness of an antibiotic or antibacterial agent in the treatment of disease, certain factors must be kept in mind. The substance should exert its effect preferably against as many dif-

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Synthetic Liquid Fuels Investigations Of the Bureau of Mines[1]

• **By Arno C. Fieldner, Sc.D.** *(University of Alabama)*
CHIEF, FUELS AND EXPLOSIVES BRANCH, BUREAU OF MINES, UNITED STATES DEPARTMENT OF THE INTERIOR, WASHINGTON, D. C.

Everyone who understands the situation is concerned about America's rapidly diminishing proved petroleum reserves. At the present rate of consumption our petroleum may last only twelve years.

Worry will be lessened, however, when citizens learn of the awareness and forethought of one of our most active governmental agencies and of its careful planning and extensive experimenting.

This paper gives an up-to-the minute picture of synthetic liquid fuels.

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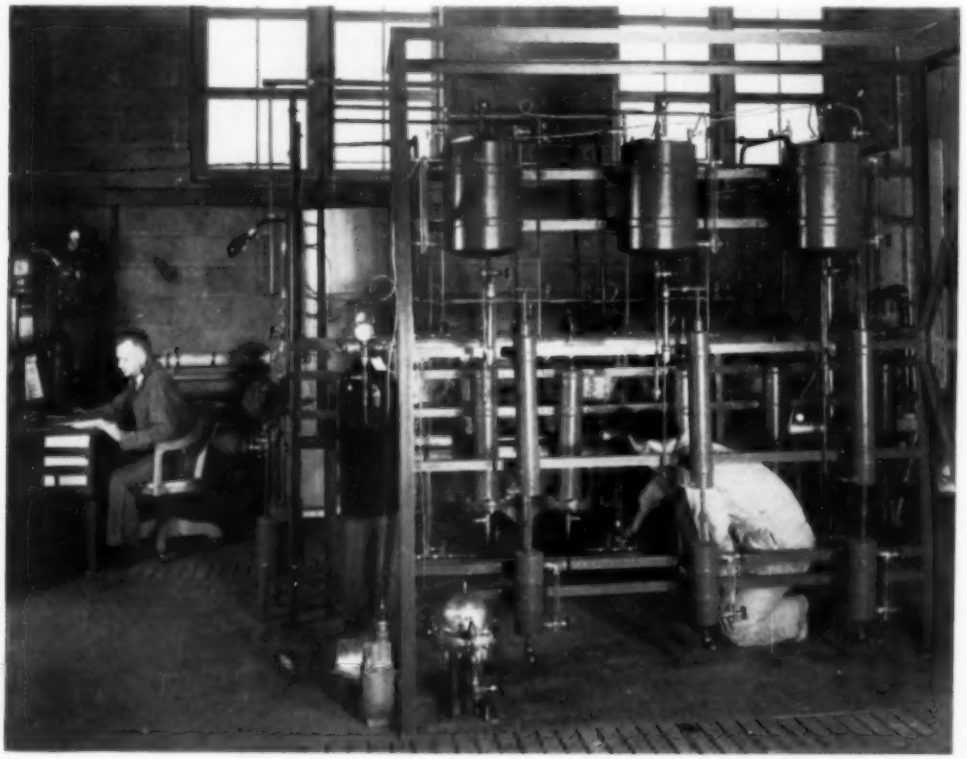
Authorization and Objectives

The Synthetic Liquid Fuel program being conducted by the Bureau of Mines is authorized by Public Law 290, approved April 5, 1944. This Act provides for the construction and operation of demonstration plants to produce synthetic liquid fuels from coal, oil shale, and other substances. The plants are to be of the minimum size that will allow the Government to furnish industry the necessary cost and engineering data for the development of a synthetic liquid fuel industry. Laboratory research and development work and pilot-plant tests needed to guide the design of the demonstration plants also are authorized. The Act provides that, in distributing the products of the plants, priority shall be given to orders placed by the War or Navy Departments. To carry out the provisions of the Act during a five-year period, appropriations of $30,000,000 were authorized.

Need for Synthetic Liquid Fuels

In terms of years' supply, the petroleum reserves of the United States are very small and discoveries of new pools are falling far short of withdrawals. The life of

[1]Published in *The Science Counselor* by permission of the Director, Bureau of Mines, U. S. Department of the Interior.



TESTING ACTIVITY OF CATALYSTS for the Production of Gasoline from Carbon Monoxide and and Hydrogen in the Fischer-Tropsch Process.

our proved petroleum reserves (20.8 billion barrels at the 1945 rate of production) is 12 years. In spite of the fact that we are drilling more wells than ever before, only 400 million barrels were discovered in new fields in 1945, when consumption was 1700 million barrels.

With the expected consumption of petroleum products, it appears inevitable that an increasing proportion of our requirements must be imported, unless alternative sources of liquid fuels are developed in this country. In the interest of national defense, it is imperative that this country avoid too great dependence on foreign sources of such a vital material as oil. This can be assured only by developing means of producing synthetic liquid fuels from our plentiful supplies of coal, oil shale, and agricultural and forestry products.

Even though all possibility of another war could be eliminated, economic considerations would require this country to develop processes for producing liquid fuels synthetically. These alternative sources of liquid fuels would place a ceiling on the price of imported oils so that we would not be at the mercy of foreign countries as we were for our rubber supplies before our synthetic rubber industry was established.

Sources of Supplementary Liquid Fuels

A broad survey of other sources of liquid fuels in the United States indicates that petroleum may be supplemented by (1) alcohols from the fermentation of vegetable matter, (2) conversion of natural gas by the gas-synthesis process, (3) distillation of oil shale, (4) liquefaction of coal or lignite by the high-pressure hydrogenation process, and (5) conversion of water-gas from coal or lignite by the gas-synthesis process. Any or all of these supplementary sources may come into use as petroleum supplies decline to the point where these higher-cost synthetic products become commercially competitive with natural petroleum products.

Alcohol

Alcohol has been and is being used satisfactorily in many foreign countries as a constituent in blended motor fuels. The place alcohol will take in providing future motor fuels will depend largely on its cost in comparison with gasoline from oil shale, lignite, and coal.

Conversion of Natural Gas

Natural gas can be converted to carbon monoxide and hydrogen, the raw materials required for the production of liquid hydrocarbons by the gas-synthesis process.

However, it is doubtful if natural gas can be considered a major source of future synthetic liquid fuels. The known reserves of natural gas in the United States are no greater than the petroleum reserves and most of this gas has a high use value in its present form.

Oil Shale

The oil-shale deposits are estimated at 92 billion barrels of recoverable oil. This amount is sufficient to supply our requirements for about 50 years at the 1945 rate of consumption of 1.7 billion barrels of oil, or about four times as long as our present proved petroleum reserves. The greater part of the shale reserve is in western Colorado, southwestern Wyoming, and eastern Utah. The assay-value of these shales is 15 to 60 gallons of crude oil per ton of shale.

Present estimates of the over-all cost per barrel of producing crude shale oil in this country vary from $1.80 to $2.50. These are educated guesses at the best. No commercial operations on which reliable estimates can be based have yet been conducted on American shales. Oil shale may prove an important supplementary source of liquid fuel in the United States. It is a material that has no practical use at present. Its utilization for the production of liquid fuels would be a sound conservation measure.

Liquid Fuels from Coal

The coal and lignite deposits of the United States, estimated at 3.2 trillion tons, could supply all liquid- and solid-fuel requirements at present rates of consumption for the next 1000 years. In general, all ranks of coal, including anthracite and lignite, may be used for the production of lignite fuels by one or more of the following processes: (a) low-temperature carbonization, (b) synthesis from water-gas by the gas-synthesis process, and (c) direct liquefaction by the high-pressure hydrogenation process. The first of these processes yields oil as a by-product, the main product being smokeless solid fuel; the other two processes yield oil as the principal product.

Hydrogenation of Coal

The coal-hydrogenation process consists of forcing hydrogen into the complex coal molecules and removing oxygen, so that its chemical constitution is changed to that of petroleum, whereupon the coal substance liquefies. This reaction is accomplished by mixing approximately equal parts of finely-powdered coal or lignite and heavy oil previously obtained from the process, and pumping this paste into a high-pressure steel vessel together with hydrogen gas at pressures of 3,000 to 10,000 pounds per square inch. A small amount—about 0.1 per cent of the coal—of a catalytic material, such as a compound of tin, is added to speed the reaction. The temperature of the reacting mass is maintained at 800° to 900°F.

The oil product from the reaction vessel is separated from the solid residue of ash-forming material and unliquefiable carbonaceous matter and is distilled into light-, middle-, and heavy-oil fractions. The light oil is refined directly to gasoline. The heavy oil is recycled for preparation of the coal-oil paste.

The middle oil from the liquid-phase stage is hydrogenated further by pumping it and hydrogen at about 3,000 pounds per square inch through a preheater into the "vapor-phase" converters. These converters are of the same dimensions as the liquid-phase converters but are filled with tungsten or molybdenum catalyst pellets. Bureau of Mines experiments indicate that 0.6 ton of bituminous coal is required for the production of one

barrel of gasoline. Progressively larger amounts of coal are required as the rank decreases. For subbituminous coal the requirement is 0.9 ton and for lignite 1.2 tons.

Gas-Synthesis Process

The gas-synthesis process (invented in Germany by Franz Fischer and Hans Tropsch) can use as raw material any coal, coke, lignite, natural gas or other carbonaceous material. The coal or other fuel is first converted with the aid of steam to water-gas—a mixture of carbon monoxide and hydrogen. This mixture of gases is in the proportion of 2 volumes or 1 volume of hydrogen to 1 volume of carbon monoxide, and after suitable purification is passed over a solid catalyst at relatively low pressures (1 to 10 atmospheres) and temperatures ranging from 306° to 410°F. Under these conditions the gases combine to form oils and waxes. The products obtained include a low-octane gasoline, an excellent Diesel oil believed to be superior to that supplied to our Navy, liquefiable gases, fuel oil, and paraffin wax. One ton of these primary products is obtained from 4 to 4.5 tons of coke, which in turn require the carbonization of 5 to 6 tons of bituminous coal, or about 0.70 ton of coal per barrel of motor gasoline.

European Developments and Their Application to American Conditions

The two principal processes for producing synthetic liquid fuels from coal were developed in Germany and that country reached a peak production estimated at 40,000,000 barrels a year of synthetic oil and gasoline before allied bombings reached the stage where their destruction exceeded German construction and repair efforts. Before the war, Germany gave little encouragement to the processing of oil shale, but when efforts to seize Caucasian oil fields had failed and the Roumanian refineries were bombed, an attempt was made to further develop oil-shale plants taken over in Estonia. After the Russians took over the Estonian plants, Germany worked feverishly to utilize the low-grade oil shale of Württemberg.

Details of new developments in Germany and the occupied countries since the beginning of the war were not available to American technicians until our victories in Europe provided an opportunity to visit the famous German synthetic oil plants. Following closely behind the armies, oil teams composed of American and British experts examined what remained of the badly bombed German plants, collected records and research documents, interrogated operating and research personnel, and sent back samples for examination in our laboratories. Seven Bureau of Mines representatives were among the 25 American investigators.

These investigators found that some important new developments had been incorporated in the large German plants, especially in refining motor fuels and in converting the primary products to a variety of necessary materials, such as lubricants, fats, soap, and margarine. However, a tremendous amount of research and development work had been done on improved processes which had never been put into commercial operation because of the pressing demand for oil and gasoline for war, which prevented shutting down the plants long enough to make the necessary changes. In some cases new plants were bombed out before they could be put into operation.

The location and seizure of a great volume of German research documents are probably the most important achievements of the oil mission. Numerous plant operating records and reports, drawings, and flow sheets were also obtained.

Members of the oil team also had an opportunity to visit French oil-shale plants, where information on new developments in processing oil shale was obtained.

Valuable reports have been contributed by Navy technical groups, which also conducted investigations of various phases of the European synthetic oil industry, especially the oil shale industry.

The large volume of documents obtained has been screened to eliminate unimportant material, and the remainder is being microfilmed for transmittal to this country. Several hundred microfilms, each one covering about 1,000 pages of German material, have been received. The Bureau of Mines has set up a Foreign Synthetic Liquid Fuels Division to handle the work of translating and abstracting the material and the preparation of final reports, which are being published.

To the extent that European processes are applicable to American coal, lignite, or oil shale, the information will be used to speed the Bureau of Mines program. Even though the nature of some of the European fuels differs somewhat from those in our country, many features of German technique and experience will be helpful in developing suitable processes for our raw materials.

Bureau of Mines Program

Immediately following passage of Public Law 290 in April, 1944, the Bureau of Mines prepared plans and estimates for carrying out the work authorized.

An Office of Synthetic Liquid Fuels was established in the Fuels and Explosives Branch of the Bureau of Mines. This office was organized in the following divisions:

1. Research and Development,
   Pittsburgh and Bruceton, Pa.
2. Synthesis Gas Production Research,
   University of West Virginia,
   Morgantown, W. Va.
3. Synthetic Liquid Fuel from
   Coal Demonstration Plant,
   Louisiana, Mo.
4. Oil-Shale Research,
   University of Wyoming,
   Laramie, Wyo.
5. Oil-Shale Demonstration Plant,
   Rifle, Colo.

Research and Development Division

The necessary buildings for the development and pilot-plant work on the hydrogenation and gas-synthesis processes for coal are being erected on the Bureau of Mines Experimental Coal Mine and Explosives Testing

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Rhode Island Holds a School Science Fair

• **By Sister Mary Constance, R.S.M., M.A.** *(Boston College)*
HEAD, SCIENCE DEPARTMENT, ST. XAVIER'S ACADEMY, PROVIDENCE, RHODE ISLAND

This is a brief account of the first Rhode Island Science Fair, written by a teacher who was one of the eleven members of the committee which planned and conducted the Fair.

There should be other regional science fairs. They stimulate students, faculty, and community to a degree not readily accomplished by other means.

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The enthusiasm aroused by the first Science Fair in Rhode Island is still strong as an enlarged committee goes to work to plan for a second Fair for 1947.

"The Rhode Island Schools' Science Fair organized by the teachers of Rhode Island's secondary schools and sponsored by the Providence Journal Company is a major step in science education and public appreciation of science in your community . . . " Thus wrote Watson Davis, editor of *Chemistry*, and Director of Science Service, to the committee on arrangements for the first Science Fair, April 8, 1946.

The Fair was an outgrowth of ideas expressed by members of a state-wide committee planning for the Science Talent Search Examination. Appointed General Chairman, Mr. J. Herbert Ward, head of the science department, Classical High School, Providence, approached the *Providence Journal* on the matter of sponsorship. From the beginning the staff of the *Journal* showed great interest in the project, gave it magnificent support, and considered that they were amply repaid for their work. From January first until the closing date of the Fair, the *Journal* followed the progress of the youthful participants in pictures, feature stories, and news items, continually keeping the public aware of what was in store for the Easter vacation.

Public, private, and parochial schools of junior and senior high school grades were represented among the 341 exhibits entered. The exhibits were classified as Junior exhibits from grades 7, 8, and 9; Senior exhibits, from grades 10, 11, and 12.

A gold medal or key was awarded to each student whose entry earned a sufficient number of points to place it within the first quarter of all exhibits of its same class in either senior or junior grouping. Each twelfth-grade student winning a gold key was eligible to compete for one of five scholarships awarded by the colleges of Rhode Island. The judging was done by men invited from the secondary schools of neighboring states.

There were certificates of merit for each grant, differing only in the color of the seal: gold for the first, blue for the second, and red for the third. The winners of the second grant were awarded, in addition to the certificate, a year's subscription to *Science News Letter* or to *Chemistry*. Seventy-five per cent of all entrants received an award.

In Rhode Island there are seventeen Catholic senior high schools. Of these, nine entered exhibits, and seven won First Grant awards. Of the eleven twelfth-grade students competing for scholarships, three were from Catholic high schools. The two scholarships available for girls were won by Catholic high school students. In competition for the three scholarships for boys, a Catholic high school student was first alternate. In the second and third grants the proportion of winning exhibits was practically the same as in the first. Many schools, both public and parochial, did not participate in this first Fair.

The people of Rhode Island were greatly interested in the results. It has of course been taken for granted that science was taught in the Catholic schools. Now our well-defined program of science education was graphically portrayed. While many of our junior high schools do not have elaborate science laboratories such as may be found in some of the public schools, nevertheless the science teaching and its results are adequate and commendable. Our Catholic senior high schools are proud of their laboratory equipment and their teaching personnel. To many, however, it was a definite awakening to find Priests, Brothers, and Sisters so interested in science and so well prepared in the field.

To the students of our schools, the Fair was an incentive to original work. The effects have carried over. During the first weeks of the school year many pupils were asking if there would be a second Science Fair and might they begin their projects.

We quote a *Journal* editorial in appreciation of the work of the participants, in past and future Science Fairs:

"There seems to be no limit to the interests of these youngsters. They have mapped the stars, dramatized the everyday wonders of chemistry, physics, biology, geology, made all sorts of clever contraptions out of anything they can lay their hands on from cardboard and tin cans to batteries, and with these home devices dramatized laws that they clearly understand.

"What will impress you particularly is that these youngsters know what they are doing. They understand. That is something these days . . . They know an astonishing amount." ●

Rubber . . . Natural and Synthetic

• **By Robert E. Powers**
THE B. F. GOODRICH COMPANY, AKRON, OHIO.

Until World War II there was little public realization of the extent to which the modern world depends upon rubber. Curtailment of the supply of natural rubber focussed attention on the synthetic substitutes that industry was able to devise and manufacture on a large scale.

This article contains important information about rubber that is not always readily available. It reviews the history of natural rubber and leads into the discussion of synthetic "rubbers" that will be published in our next number.

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Part I. Natural Rubber

Before Japanese bombs shattered the uneasy peace of the American people when they cascaded on Pearl Harbor on Sunday, Dec. 7, 1941, any writer on rubber had, generally speaking, only to consider the natural type in fashioning his article, and needed to give slight attention to American-made or synthetic rubbers. This does not mean, of course, that a tremendous volume of work on synthetic rubber had not already been accomplished by the nation's scientists, or that rare and highly technical papers on their efforts had not been presented. But these, in comparison to the flood of information on natural rubber, were but a trickle and were addressed, not to the general public, but to other technical men.

But the men of Nippon quickly focussed attention on the man-made, or American rubbers, and for the last five years they have been about the only types that have been the subject of widespread discussion. This the Jap warriors did when, following their amazing attack on our principal bastion in the Pacific, they quickly overran the Malay peninsula, Java, Sumatra and other areas from which 90 per cent of the product called natural crude rubber came to the United States. The center of this rubber producing territory is Singapore. Remember when it fell, cutting off practically all our supplies of natural rubber?

But now the wheel of destiny, accelerated by our armed forces, has revolved full circle again. The Japanese, driven back to their homelands have relinquished their iron grip on the millions of acres of rubber plantations. They had believed that the capture of these would be one of the military blows which would force their foes to yield, since without adequate rubber modern war cannot be fought, any more than our present day peacetime civilization could long function without it.

With the plantations again producing natural rubber by the hundreds of thousands of tons, and in ever increasing quantities, and the gigantic units in the United States turning out American rubbers (synthetic) at the rate of nearly a million tons annually, (1946), it is necessary now to discuss both the natural and synthetic types, each of which is playing an important part in post-war reconversion. The ultimate sphere into which they will fit is still clouded in the maze of diplomatic and economic tangles that are inevitable with a material which probably has as many ramifications as any which serves modern man.

Courtesy, The B. F. Goodrich Company
NATIVE TAPPING A RUBBER TREE ON A PLANTATION.

Natural rubber first came to the attention of the civilized world following one of the voyages of exploration of Columbus to this hemisphere, (1492-1503). Report has it that one of his sailors going into a South American village gaped in amazement as he watched the lithe, brown natives playing with a ball unlike anything he had ever dreamed of. For it was a ball which bounded and rebounded as the players, their bodies glistening in the sun, attempted to follow its swift, elastic flight. The crewman reported this awesome discovery to his fellows, and some of the balls were taken back to Spain on the galleons as prizes for Queen

Isabella and her court, where they excited the same wonderment they had among the discoverers of the New World.

Among the first written references to natural rubber is one by the Spaniard, Gonzalo Fernandes D'Oviedo y Valdas who described the game of "Batos" played by the Indians of the wondrous lands which had just been touched by the white man for the first time. Later Spanish writers described these balls in greater detail, and related how they were formed from the "milk" which oozed from certain trees, and which became a solid when it was slowly turned over smoky fires. The "milk" is what later become known as rubber latex, and the process of evaporating the fluids from it and making it a coherent mass is now know as rubber coagulation. These writers also described some of the crude rubber boots and overshoes which the natives fashioned from the latex, and some of these found their way to Europe.

More than two centuries passed after Columbus' voyages of exploration with but scattered references to the material in European writings, and only an occasional sample finding its way into the curiosity cabinets of museums. It remained for the French government, in 1731, through the medium of Charles de la Condamine, scientist and naturalist, and the engineer Fresneau to reveal really pertinent details about this new gum, its origin and methods of application, and some of its possibilities. Their expedition was originally intended to study the shape of the earth, and five years after it was dispatched, in 1736, they sent back from the Amazon to the French Academy a few rolls of the resinous, dark-colored material which the French called "caoutchouc" indicating that it came from a "weeping tree." They also made studies of the natives' production methods, described how linen was covered with the material and used like oilcloth, and waterproof shoes and water bottles were fashioned of it. They even outlined potential uses for the rubber, all of which have since succeeded, including waterproof sails, hose for divers, and bags in which to preserve food. They warned, however, that all these articles would have to be manufactured where the trees grew, because the juice clotted so quickly after it oozed from the trees. This latter, of course, has proved not true, as is evidenced by the rubber plants situated in virtually every corner of the world.

Just a few years before our War of Independence, samples of this strange material reached England. There, in 1770, one of the foremost chemists of his time, Joseph Priestly, who discovered the nature of oxygen, was toying with one of the pieces, as he wrote in pencil. Consciously or otherwise, he rubbed some of the material across his notations. They disappeared before his eyes. "Why, it rubs!" he exclaimed, calling in his astonished associates, and there and then the English name "rubber" was applied, and thus it has been called in our language ever since. The price for the minutely small quantities of rubber then in Europe, has been reported at $175 a pound.

Experiments to dissolve the coagulated material continued in the few European laboratories dedicated to science so that use could be made of it, but it was not until 1791 that the Englishman, Samuel Peal, started the first commercial processing of rubber in the civilized world by dissolving it in turpentine, and then waterproofing fabric by coating it with the solution. Twenty-three years later Thomas Hancock established the first rubber factory in England, and in 1823 Charles MacIntosh established a plant in which he bound two layers of cloth coated on one side with rubber, and thus gave his name to a type of garment still used all over the world.

Meanwhile, in the recently created United States, interest in the material was mounting year after year as our trading ships returned from South America with some of the crude articles made by the natives, or with samples of the gum itself. These intrigued especially a young man, Charles Goodyear, who became a virtual fanatic on the subject, sacrificing his own welfare and that of his family in his search for the knowledge which would really release the material from the terrific limitations it then possessed. For its prevailing weakness in its natural state was that it became tacky in the summer, and brittle and stiff in winter's cold, so that articles fashioned of it had only a small usefulness.

Then, in 1839, after heating rubber mixed with white lead and sulphur on the kitchen stove of his home in Woburn, Massachusetts, Goodyear learned that if he subjected the mixture to a temperature above 212 degrees, it lost its tackiness, went back to its original dimensions after stretching, was not softened by heat, or stiffened with cold. The secret of utilization for a versatile material, without which our mechanized civilization could not exist, had been wrested from nature by a determined experimenter.

With Goodyear's discovery of vulcanization (after Vulcan, the god of fire), activity in rubber spurted all over the world. In the 107 years since that epoch-making development there have been literally thousands of achievements in making natural rubber the servant of man. Nelson Goodyear, brother of Charles, created hard rubber, Ebonite, in 1860 by increasing the amount of sulphur in compounds. Arthur H. Marks perfected his alkali process of reclaiming rubber which stimulated a great increase in the use of reclaim, or scrap rubber, by 1898. George Oenslager developed organic accelerators in 1906. They cut down the time required for vulcanization and improved the service life of rubber articles even when made from lower grade, lower priced rubbers. It has generally been acknowledged that Oenslager's contribution to rubber science was second only to the discovery of vulcanization.

Among the most recent scientific achievements has been the creation of antioxidants, or age resisters. A serious shortcoming of most rubber goods for many years had been their relatively short life, especially

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Can Research Alleviate Some of the Tragedies of Aging?

• By C. M. McCay, Ph.D. *(University of California)*
ANIMAL NUTRITION LABORATORY, CORNELL UNIVERSITY, ITHACA, N. Y.

For twenty years workers in the nutrition laboratory at Cornell University have experimented with animals in order to learn how to prolong the productive life of man by retarding the onset of the degenerative diseases peculiar to old age. Some of the results of their study are described in this article.

You will be interested to learn of the relationship between longevity and diets that are excellent in quality but low in calories; the effect on the life span of adding coffee or vitamins to typical adequate diets; and the effect of underfeeding on the prevalence of cancer.

Is it mere coincidence that thin men beyond middle age are likely to attend the funerals of their obese colleagues?

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In America today are millions of people who would have perished as infants if they had been born a century earlier. Due to purer water supplies, improved sanitation and better control of diseases caused by bacteria and malnutrition, millions will survive to celebrate more than sixty-five birthdays. Research in nutrition, biochemistry, bacteriology and many other fields has made this survival possible.

This large group of people who can certainly expect to live through many of the "borrowed years" of life may either pass these years in happiness, or in tragedy and sorrow, depending upon the diseases that attack their bodies. These afflictions of the later years not only plague the individual but may modify profoundly the lives of his children and grandchildren who have to face the financial burden of keeping an invalid. The increase in numbers of the aged makes it important that great progress be made in the coming years to effectively alleviate the illness of the old.

Although scientists of all ages have been concerned with problems of aging, the one who first clearly outlined methods of attack upon these was the great scholar, Roger Bacon (1214-1294).

Bacon advocated a much better use of the years of life and the employment of experimental science to insure optimum health in old age. Thus he wrote: "You live as though you expected to live always. Your frailty never occurs to you. Like mortals you fear all things, like immortals you desire all things. You will hear many say 'At fifty I shall retire', 'My sixtieth year will free me from business'. Who will permit these plans of yours to mature as you now arrange them? Are you not ashamed to reserve for yourself only the remnant of your life, and to destine for the good of your soul only that time which you can employ in no other way?"

In foreseeing the usefulness of research in preventing illness in the later years Bacon wrote: "that the wonderful and ineffable utility and splendor of experimental science may appear and the pathway may be opened to the greatest secret of secrets." Furthermore he stated, "Not only are the remedies possible against the conditions of old age coming at the time of one's prime and before the time of old age, but also if the regimen of old age and senility can be retarded, so that they do not arrive at their ordinary time, and when they do come they can be mitigated and moderated, so that both by retarding and mitigating them life may be prolonged beyond the limit."

Seven hundred years have elapsed since these words were written. Progress in science has surpassed the most fantastic dreams of the wise scholars of the middle ages. However, almost no advance has been made in preventing the common diseases of old age such as cancer, arteriosclerosis, and degeneration of the kidneys.

For centuries biologists have recognized that man has a superb means of attacking these problems since many common domestic animals that are widely used in laboratories pass through the various stages of life ending in senility in a few years. Thus a common white rat ages in ten days as much as a man does in a year. Likewise a dog or a sheep at the age of 12 to 15 years compares with a person of seventy. Thus man has the opportunity to study ways of alleviating the cancers, calcified arteries and degenerated kidneys that occur in white rats when this species is about two years old. From these he may learn facts useful to man. This rat species has laid the basis for much of the modern knowledge of nutrition and likewise may provide knowledge for preventing many of the diseases of late life.

Progress in this field has been very slow, however, since few scientists have the patience to invest even a few years in observing rats from birth until they die of old age. Furthermore it has been very difficult to finance such research since it is expensive and must continue for many years in succession. Hence slow progress has been made in such fields as cancer research because the financial support has gone largely into the study of cancer after it appears rather than into the

determination of the causes of the disease. These causes will probably be discovered by studies in basic nutrition and pathology rather than in studying the conditions after the disease has developed.

The progress in learning to alleviate the diseases of old age will probably be made by a team of scientists, namely by a specialist in nutrition working with one in pathology. The nutritionist knows how to design diets and control such factors as the growth and environment of experimental animals like white rats; at death the pathologist can dissect the bodies of the rat to determine the nature of the diseases that afflicted the animal in old age after it has been subjected to a given diet or regime by the nutritionist.

Since 1927 workers in the nutrition laboratory at Cornell University in Ithaca have made use of these lower animals, especially the white rat and to a lesser extent the dog, to learn how to prolong the productive life of man. Many have misinterpreted our ideals and thought we were merely attempting to learn how to stretch the period of senility or how to keep men alive with one foot already in the grave. Quite the opposite is true since we have attempted to learn how to keep people healthier in old age and put more "life into the years."

Our experiments really began in a trout hatchery in Connecticut in the summer of 1927. Feeding trials were run with brook trout in order to determine ways of rearing them more economically. In the course of this work it was found that trout that grew slowly on deficient diets lived about twice as long as those that grew rapidly. For many years life insurance companies had known that men who kept thin during the latter half of life attended the funerals of obese colleagues. The results with trout indicated that there might be a general biological law relating such factors as slow rate of growth, thin adult bodies and life span. For most higher animals the length of life span is determined by species and the extent of degenerative diseases. The lengthening of the life span of a species usually means that one has found a way of retarding the onset of degenerative diseases.

Late in 1930 experiments were started in the laboratories at Cornell to determine if it might prove possible to extend the life span of rats by feeding various diets from the time of weaning. The first studies were similar to those made earlier with trout. Two groups of rats were fed diets excellent in quality but only sufficient in amount to permit very slow growth. In other words, each rat was allowed barely enough food to maintain life but this food was rich in minerals, vitamins and protein. Such an experimental diet contrasts with that available to people in famine areas, such as India, inasmuch as these famine diets are usually very poor in vitamins, proteins and minerals as well as calories.

The results of this first study were clear cut. Rats fed for long periods upon diets barely able to keep them alive remained youthful and active, and were in prime condition when control animals fed liberally grew senile. This method of extending the span of life raised many questions but settled one definitely, namely that Roger Bacon was right, and that man could greatly extend the span of life of experimental animals by the use of modern science. This first experiment indicated also that rats maintained upon diets providing restricted calories did not suffer from such afflictions as cancer until long after the controls had died with the disease. A careful search of the literature revealed that as early as 1909 Moreschi had shown that underfed mice were much less subject to cancer. Such observations gave new hope to the whole field of cancer research because they afforded positive methods of attack upon the problems.

In the course of fifteen years this experiment with rats was performed three times. The outcome was always the same, namely that animals kept thin on low calory intakes far exceeded the span of life of the controls fed liberally.

Through the cooperative labors of a group of researchers that included J. A. Saxton, Leroy Barnes, Gladys Sperling and many others, it was established that rats retarded in growth and kept thin during adult life lived much longer because the degenerative diseases of old age did not become troublesome until the rats were about 1,000 days old, or equal to men who had reached 100 years of age. The oldest rats in these experiments lived over 1400 days, equivalent to more than 140 years for a man. An average rat usually lives about 700 days.

Many other experiments were run with rats. Thus it was found that rats obliged to keep thin after they reached a middle age of about one year lived longer than those allowed to fatten. Some groups of rats were kept thin by high quality diets low in calories, and others were obliged to exercise every day by running in a rotating barrel. The results were the same, namely longer life, for thin rats.

Special microchemical methods were employed by Drs. A. B. Hastings, O. H. Lowry and associates at Harvard in studying the tissues of the long-lived rats retarded in growth. Evidence was found that these tissues of retarded rats that were really old had a composition in some respects similar to that of young animals.

In recents years two further studies with rats have been made at Cornell to determine if basal diets recognized as adequate could be further improved by the addition of supplements of natural foods. In one study four different groups were fed adequately and then given extra allowances of milk to one group, liver to another, starch to a third, and cane sugar to a fourth. No differences in life span resulted. This indicated that if an animal eats an adequate amount of a high quality basal diet, the remaining sources of calories are not important. The average child tries to do the reverse, namely to get a substantial part of his day's food from sugar in the form of candy or soft drinks. He then

finishes his diet with foods at the family table. This is not sound nutrition.

During the past four years another study with white rats has been completed at Cornell to determine if the typical human diet consumed in the northeastern part of the United States can be improved by either the addition of foods richer in vitamins or by adding vitamins such as those used to enrich bread. The length of life of these rats was not extended by these additions. In these studies a moderate allowance of coffee in the form of a beverage as drunk by man was given half the rats after they reached adult size. This coffee was equivalent to that consumed by an adult person drinking one to two cups daily. The lives of the rats were not shortened by this amount of coffee.

In this latest study a careful record was kept of the mothers that produced the rats used in the experiment. Inheritance proved to be an important factor since a relatively small number of mother rats provided most of the offspring that lived long or lived a short span. This indicated that inheritance is very important in pre-determining the age of rats just as it is in the case of man.

These studies represent only a beginning in attempts to learn how to alleviate the diseases of old age. If man invested as much money in such studies as he has in developing atomic bombs and weapons of destruction, he would soon discover many ways for preventing the diseases to which he is now doomed in later years. However, even without laboratories and even with such simple animals as insects any student can study gerontology. Thus in some obscure attic some natural investigator may help to unravel the secrets of a happy old age. Achievement in this field of gerontology is possible for anyone with a fine mind no matter how poor his physical equipment, because all animals and plants age no matter whether they be cockroaches or oak trees. ●

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The Birds of the Air

(Continued from Page 4)

Observation of the orderly processes of nature throughout the seasons and the wonders of plant and animal life brings a realization of fundamental truths. There are few avocations of such lasting spiritual value as the study of natural science in that best of laboratories—God's outdoors. ●

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Profusely illustrated in color and black and white, showing field marks of all species found east of the Rockies. Convenient pocket size.

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Complete information regarding birds of the region, with 22 color plates including 118 paintings by George M. Sutton.

Photograph by Hal H. Harrison
BABY FLICKERS BEG FOR FOOD.

The Smithsonian Institution Celebrates Its One-Hundredth Birthday

• **By W. P. True, Ph.B.** *(Hamilton College)*
CHIEF, EDITORIAL DIVISION, SMITHSONIAN INSTITUTION, WASHINGTON, D. C.

This article will astonish those who think vaguely of the Smithsonian Institution as an old-fashioned building in Washington housing a museum containing millions of interesting specimens.

Actually, the Smithsonian is one of America's most valuable agents for the creation and diffusion of knowledge. Its many collections for study, its geographical explorations, its astrophysical researches, its archeological investigations and its other activities have contributed much to the scientific progress of the past century.

Teachers of science should know this Institution better.

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The Smithsonian Institution is an American tradition. Five generations of Americans have been familiar with the name "Smithsonian" and have associated it—perhaps more or less vaguely—with some sort of a cultural organization and museum in Washington where information on anything under the sun may be obtained. Relatively few people, however, have known of its origin and its gradual but steady expansion as a national scientific institution.

As the Smithsonian Institution crosses the hundred-year mark, it is well for it to pause and look back over a century of activity to see how it has succeeded in carrying out the behest of its founder and to try to discern how best it may serve mankind in the centuries to come. The Smithsonian had a definite beginning but has no foreseeable end. Its stated purpose knows no time or space limits, and it will go on through the centuries, changing with a changing world and so adjusting itself that it may fill a useful role in the upward struggle of mankind.

Origin of the Institution

James Smithson, the founder of the Smithsonian, was not an American, but an Englishman. He was graduated from Pembroke College, Oxford, in 1786, and the following year was admitted as a Fellow of the Royal Society because of his proficiency in chemistry and mineralogy. He immediately set about the scientific investigations that attracted him so strongly, working both in England and in France. Although perhaps not to be classed as a great scientist, nevertheless James Smithson was one of the leading investigators of his time, and he contributed no little to progress in those early days of science. What is even more important, however, in the light of his final act that brought him fame, is his almost modern attitude toward the importance of exact knowledge and his eagerness to aid in expanding mankind's mental horizons.

When Smithson died, he left his fortune of $550,000 to the United States of America, to found at Washington an institution for the increase and diffusion of knowledge among men. Smithson's will is a clear statement of his own ideal. Far in advance of his time, he saw that man could hope to better himself and his living conditions only by taking knowledge out of the hands of a chosen few and making it available to all. Therefore, in writing his will, he hoped that in addition to perpetuating his name he might project into the future his own ideal of causing the value of greater knowledge to be more widely appreciated.

Congress debated for eight years as to the best methods of carrying out the bequest, but finally a bill to establish the Institution was passed by Congress and approved by the President on August 10, 1846.

The first Secretary was Joseph Henry, an outstanding scientist, and Henry's plan of organization was so sound and far-seeing that it has never been found necessary to make any material change in its basic principles during a century of operation. For the increase of knowledge Henry's plan contemplated the support of scientific research, both through major projects at the Institution itself and through grants to outside workers in promising fields of investigation. The diffusion of

RECORDING THE SUN'S RADIATION at the Smithsonian Solar Observing Station, Mount Montezuma, Chile.

knowledge he proposed to accomplish by publishing the results of original research in a series of memoirs and distributing them throughout the world.

The Nation's Treasure House

The museum provided for in the act of incorporation has developed from the original collection of minerals in the Smithsonian Building into the great United States National Museum comprising today more than 19,000,000 specimens housed in three buildings of its own. The whole presents a panorama of the natural history and anthropology of America and of the world, as well as of engineering, the useful arts, and history. It is high on the list of points of interest in Washington for the ever-increasing multitude of visitors to the Nation's Capital. In the last year before World War II, the annual count of visitors reached a peak of slightly over two and one-half million.

To the visitor, the public exhibits seem to be the important part of a museum, but the members of the scientific staff know that the soul of the museum resides in the systematically arranged study collections, where fundamental discoveries of new knowledge are constantly being made. Here new kinds of mammals, birds, fishes, insects, and many other life forms are discovered; minerals and meteorites are analyzed and described; the fossil bones of long-extinct animals are identified and pieced together to recreate the faunas of past geologic eras; and large series of human skeletal remains are subjected to standard comparative measurement. Many other types of basic research yield results of cultural and practical value to mankind.

American Indians

After Major J. W. Powell's explorations in the West, including the first descent of the Colorado River, the Government surveys were organized in 1879 as the United States Geological Survey, and the study of the Indians was placed under the Smithsonian Institution through creation of the Bureau of American Ethnology.

The Bureau's regular year-by-year work has included the systematic study of the language, customs, beliefs, myths, and organization of the numerous tribes throughout America. Its staff members and collaborators have worked among the numerous West Coast tribes, the peaceful Pueblos with their cultivated fields and aboriginal "apartment houses," the marauding Navaho and Apache of the Southwest, the warlike Sioux, Omaha, Mandan, and other tribes of the Great Plains, the Iroquois of the Northeast with their league of nations in the Stone Age of America, the Southeastern forest tribes, and many others from the snow-covered Arctic to the tropical jungles. From these widespread investigations has come a stream of publications that make a sizable library of Indian lore.

Archeology has been a more or less prominent feature of the Bureau's work, and knowledge has been made available concerning many ancient Indian mounds, shellheaps, cliff houses, and other prehistoric works with their evidences of prehistoric cultures. One of the latest of Smithsonian archeological studies is that of Folsom man, that mysterious early American whose handiwork has become well-known but whose skeletal remains have yet to be found.

Life Depends on the Sun

On lonely mountain peaks on two continents Smithsonian observers record the day-by-day variation in the radiation coming to us from the sun. When we stop to consider that the energy riding the solar rays is responsible for all life on this earth from the lowest type of plant to man himself, for seasons and climate with their storms and droughts, and basically for all man's industries through the stored energy in oil and coal, the importance of studying the sun becomes obvious. We now have a considerable body of recorded knowledge as to its composition, temperature, spectrum, and radiation, no small part of which has come from the researches of the Smithsonian Astrophysical Observatory, founded by Samuel Pierpont Langley, third Secretary of the Smithsonian.

After the establishment of the Observatory, Langley and his assistants made observations on solar radiation at Washington, although the atmosphere there was highly unsuitable. The solar constant of radiation had from the beginning shown variation regardless of observing conditions, and from this time on the study and recording of this variation became a leading purpose of the work. Today observations are made regularly at three stations—Mount Montezuma, Chile; Table Mountain, Calif.; and Burro Mountain, N. Mex.

As the result of Smithsonian astrophysical research, there are available to the world almost daily values of the sun's radiation since 1923. Even were these records not of immediate usefulness, they would be of incalculable interest and value to future generations, not only for use in various researches, but also as indicating whether the sun's heat is increasing or diminishing over the centuries.

In 1929 a new type of research was inaugurated through the establishment of the Division of Radiation and Organisms. The division investigates the effects of radiation of various types and of different wave lengths on living organisms, chiefly plants. Like other phases of Smithsonian research, this work is fundamental in character and is not restricted to work of an immediately practical nature. The effort is to discover basic laws and principles, in the sure knowledge that all such discoveries will eventually be put to use in promoting the welfare of mankind.

Live Animals

The National Zoological Park, established in 1890 under the administration of the Smithsonian Institution, began with a small group of animals brought to the Institution to serve as taxidermist's models. Professor Langley interested a number of Congressmen in the idea of a National Zoological Park, and under authorization of an Act of Congress, a tract of 175 acres of land

in Rock Creek Valley was obtained. The purpose of the Zoo was stated to be "the advancement of science and the instruction and recreation of the people."

From the original nucleus of 185 animals, the national collection has grown year by year until in this 100th year of the Smithsonian Institution, the total population of the Zoo is over 2,600, made up of 677 mammals of 209 different species, 909 birds of 322 species, 447 reptiles of 105 species, and smaller numbers of amphibians, fishes, insects, and arachnids.

Smithsonian Explorations

In these days of atomic energy, electronics, jet propulsion, television, and similar spectacular scientific achievements, the public is likely to get the impression that nearly all science is physical science. It should not be forgotten, however, that to achieve anything like a mastery of nature, mankind has need also of the natural sciences—biology, geology, and anthropology—and in these sciences exploration plays an important role.

Smithsonian explorations started almost with the founding of the Institution in 1846, and although every continent and large island group has been visited by numerous Smithsonian expeditions, yet for geographic reasons North, South, and Central America, the West Indies, and Alaska have been most intensively explored. Among the remote localities explored scientifically may be mentioned Antarctica, New Guinea, Borneo and Celebes, Midway Island, Wake Island, Siam, Kashmir, Mongolia, the Aleutian Islands, Greenland, Algeria, Liberia, Tanganyika, Patagonia, the Galápagos Islands, and Easter Island. Tangible evidences of Smithsonian explorations in all parts of the globe may be seen in the exhibition and study collections of the National Museum, and in the pages of Smithsonian publications.

Art Galleries

Art may seem on first thought to be so far removed from the world of scientific research that the combination of the two under the administration of a single institution might appear incongruous. However, it must be remembered that James Smithson in his will placed no restrictions on the kind of knowledge he wanted increased and diffused. Recognizing this fact, the members of Congress who drafted the act of incorporation of the Smithsonian Institution included among the adjuncts of the Institution "a gallery of art." From a very small nucleus, art under the Institution has developed and expanded until at the close of the first hundred years we see three distinct bureaus entirely devoted to it, with two splendid buildings and art collections that rank among the best in the world today.

The earliest was the National Collection of Fine Arts, which has developed through the years into a large aggregation of art works, including many old masters. In 1906 Charles L. Freer, of Detroit, gave to the Institution in trust for the American people his splendid collection of American and Oriental art objects and a gallery building to house them.

THE ORIGINAL STAR SPANGLED BANNER, U. S. National Museum, Smithsonian Institution.

In 1937 Andrew W. Mellon gave to the people of the United States through the Smithsonian Institution his unexcelled art collection and a $15,000,000 gallery building, the whole to be known as the National Gallery of Art. Created as a bureau of the Institution, the Gallery is administered by a separate Board of Trustees. Starting with Mr. Mellon's own collection of 111 choice old masters and 21 pieces of sculpture, the National Gallery collection has already grown greatly in size and importance through the gifts of several valuable assemblages of art works, including the Kress, Widener, and Rosenwald Collections. With these and numerous other additions received as gifts, the National Gallery became from the start a center for the study of art in the United States and one of the great galleries of the world.

Smithsonian Diffusion of Knowledge

The first series of publications established by Secretary Joseph Henry was the quarto Smithsonian Contributions to Knowledge, and the first monograph to appear in the series was Squier and Davis' "Ancient Monuments of the Mississippi Valley," published in 1848. A few years after the Contributions started there followed the Smithsonian Miscellaneous Collections, the first paper in which was Guyot's "A Collection of Meteorological Tables." This was later divided into several volumes, entitled "Smithsonian Meteorological Tables," "Smithsonian Physical Tables," and "Smithsonian Geographical Tables," to which were added later "Smithsonian Mathematical Tables—Hyperbolic Functions" and "Smithsonian Mathematical Formulae and Tables of Elliptic Functions." These tables have been among the most useful of all Smithsonian publications. Another series of volumes in the Miscellaneous Collections that have proved to be of great value to research workers, especially in the field of meteorology, appeared under

(Continued on Page 23)

Tyrothricin

(Continued from Page 7)

ferent disease producing micro-organisms as possible, and *in amounts that are not toxic* to the individual being treated. As indicated above, tyrothricin has a fairly wide field of antibacterial activity. Furthermore, it has not been shown to have any harmful effect on tissues or on the body itself when it is applied in the proper dosage and manner, by physicians or veterinarians skilled in the treatment of human and animal diseases. Tyrothricin is a relatively stable substance; suspensions of the antibiotic in the form prepared by various pharmaceutical houses appear to maintain full bacteriostatic activity for several months. Sensitive bacteria, those against which tyrothricin has an antibacterial effect, are killed within an hour, thus indicating a swift local action.

When applied locally by instillation, irrigation, or as a wet dressing, tyrothricin has found a wide field of usefulness in human and veterinary medicine for the treatment of various infections due to micro-organisms sensitive to its action. The best results usually are obtained in localized infections due to gram-positive bacteria, since the action of tyrothricin is greatest among this group of organisms. In addition, the focus of infection should be readily accessible for irrigation or direct application so that the antibiotic can come in direct contact with the offending organism. In some instances, tyrothricin may be incorporated in an ointment base for application to the skin for such conditions as impetigo, dermatitis vegetans, infectious eczematoid dermatitis, and ulcers. The fact that tyrothricin has an antibacterial effect on anaerobic streptococci and beta hemolytic streptococci might be a point in favor of the therapeutic use of this substance in the treatment of infections caused by these organisms, since the former usually are resistant to the action of the sulfonamides, and the latter are extremely susceptible to tyrothricin.

Table I summarizes the various conditions for which tyrothricin has proved to be an effective therapeutic agent in the human field.

Table I

CONDITIONS BENEFITED BY TYROTHRICIN THERAPY

Infections of the Ear, Nose, and Throat
- sinus infection
- mastoid infection (after operation)
- otitis media (inflammation of the middle ear)
- oral antisepsis

Infections of the Skin
- eczematoid dermatitis of extremities
- carbuncles
- boils
- purulent skin diseases

Genito-urinary Infections
- cystitis (inflammation of the bladder)
- trichomonas vaginitis

Infections of the Eye
- pneumococcic conjunctivitis
- epidemic keratoconjunctivitis (shipyard fever)
- keratitis (inflammation of the cornea)
- blepharitis (inflammation of the eyelids)
- dacryocystitis (inflammation of the tear sac)

Surgery
- empyema
- infected wounds
- infected burns
- abscess
- leg ulcers
- osteomyelitis (inflammation of the bone marrow and/or bone)
- pilonidal cysts

Tyrothricin, of course, is only one of several antibiotics that play an important part in the prevention and treatment of disease. Intensive studies are being carried out in many universities and commercial laboratories in the search for new and perhaps better antibiotic agents that may be effective in smaller amounts, that are less expensive, or that may have a broader field of activity against the pathogenic bacteria causing disease in man and animals. ●

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A Summer Course in Field Biology for High School Students

• **By Edith R. Force**
SCIENCE DEPARTMENT, WOODROW WILSON JUNIOR HIGH SCHOOL, TULSA, OKLAHOMA

Courses in biology have an increased interest and special values when taught in summer in the great outdoor laboratory.

This is an account of an accredited course in field biology that has been operated successfully for seven summers. The widely known teacher in charge gives a helpful and detailed account of the manner in which the course is conducted. She advises what to do and what not to do in planning courses of similar nature.

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More than a few writers on 'teen age guidance express the opinion that our so-called juvenile delinquency is not a youth problem so much as it is a teacher-parent problem. To the agriculturist, conservation of the soil is all important to a democratic America. As a biologist we agree with both, but we would go further and say that the biological sciences should occupy one of the most important places at all levels of education since they deal with the understanding of nature and how it benefits society. Conservation, then, must deal primarily with people!

If the major purpose of education is training in desirable living, we may define the purpose of conservation education with Jay N. Darling, "to develop through habits, attitudes and ideals to lead to the development of better citizens."

Does it not seem important, then, that trained adults, such as teachers, should help guide the hours of youth so that there is no opportunity to develop habits wasteful of time and energy?

Something of this idea was behind our first summer course in Field Biology for high school students, which has just closed its seventh season. This paper is written in response to a request for pointers on "how-to-do-it," and we hope that it may serve as an impetus for other groups to pioneer wherever a dozen adolescents may be brought together for six or eight weeks of "work that's like play" during the summer leisure time.

The success of a field biology course depends upon many factors. The naturalness of field trips, age being no barrier, is a great advantage from the very beginning. The desirable leader has an insatiable curiosity—there is no need to designate it the research attitude—about the outdoors. He or she probably has already been affiliated with groups of 'teen agers such as Scouts, Nature Camps, or Science Clubs.

An experienced instructor having the required educational certification should have no difficulty in standardizing the scholastic credits given in this type of private class if the time schedule fits that of the State Department of Education. Such conditions should be clarified in each case before beginning the class. While the teacher may not issue the credits, arrangements may be made whereby a student finishing the equivalent of the standard set for the grade may be "recommended for credits" to the high school registrar. In the Tulsa city school system this amounts to "one year of high school science credit as given in the 9-10-11-and 12 grades".[1] If taken between eighth and ninth grades it will be junior high school credit. If taken after ninth grade it is senior high school credit. Occasionally a student who is serious about biological science will obtain both. Although the number of cases, about 90, is not extensive enough to do more than merely indicate the uses the students make of these credits, a study of the results, which will be presented later, has definitely marked the "worthwhileness" of the effort made to direct the time of the young people into productive channels.

Definite arrangements should be made with the Board of Education regarding finances, the use of public property such as laboratory equipment and library books, payment for loss or breakage, and any other matter that may be a local problem. The administration may place the headquarters and equipment at the disposal of the teacher, considering the work a community cooperative effort. Or the Board of Education may develop the course as a part of the regular summer school project, paying the teacher a salary and receiving the student tuition fees. The Board may decide to charge rental for the use of the laboratory room and equipment, allowing the teacher to "sink or swim" on his own.

In each case, the *esprit de corps* of the administration, the community, the parents, and especially the pupils themselves, is most important. To assume from the beginning that "we are all here because we *want* to be here" helps to set up "an informal, pleasant, healthful, good-humored enrichment of everyday living."[1] Never does the day come when the instructor is not also a pupil learning with the merest beginner. However, if the instructor has walked that way before, he is able to insure confidence, sincerity, and faith. His experience makes it possible for many lessons of desir-

1. Force, Edith R., *Field Biology Courses for High School Students as an Aid in the Promotion of Conservation Education.* School Science and Mathematics, June, 1946, pp. 560-564.

able living to be learned and taught from the Book of Nature in the all-too-short six weeks together.

It has been said that directors of summer camps do not find biology teachers satisfactory as camp nature instructors; but if this course is to be accredited, the teacher who is trained to prepare and use courses of study will be very likely to conduct a successful, smooth-running class group. If the instructor has had the advantage of personal training in any of the fine university biological stations the course of study is "a natural". A concept of the biotic communities may be established. Familiarity with living things in their natural environment gives us thrills which are lifelong in their enrichment. To learn courage by watching the fearlessness of a mother bird defending her nest till the very last possible moment of escape remains; to be silent and listen to a painted bunting almost burst its throat while you crouch beneath the bush he adorns; to learn self reliance in meeting the danger of a poised rattlesnake; to take the inevitable punishment of becoming too familiar with the protective devices of the cactus; to meet sunshine, rain, dust, and steep hills, are all parts of the course of study which may never get into the field note-books, or be recorded for the "grading". Yet I wager it is these ways of living which draw forth repeated statements of enthusiasm from the students for "this kind of school".

It is obvious that everything about everything can not be learned in one or many summers. It is the joy in the familiarity and variety of adventure which makes an annual course, once started, most satisfactory for both students and teachers. It seems desirable to hold each student responsible for acquiring a basic general background of classified fundamental knowledge of the fauna and flora of the area. In addition, each should be encouraged to develop the research attitude in a project of major interest. This might lead to the publication of a calendar of the breeding birds of the local area, or to the establishment of new records of plant species, or an annotated list of the amphibians and reptiles of the vicinity. The opportunity for local exploration is endless in most communities.[2]

Granted that physical conditions are satisfactory, that the course of study and scholastic standards are acceptable for certification of credit, and that the students have well developed learning attitudes, it still remains for the instructor to inject numerous variations in activities, to originate successful ways to accumulate knowledge, and to be alert to adapt suggestions from the group which have possibilities of success. For example, a little care is needed in choosing a place to eat the noon lunch where the group may retain its one-ness, and so that each may have sunshine or shade, grass, or rocky ledge, or tree trunk all to his liking. Conversation remains general, witty, stimulating, and care-free. It usually deals with unanswered questions about nature.

2. *Opportunity for Investigation in Natural History by High School Teachers.* Reprinted from the Journal of the Michigan Schoolmasters' Club, 1933. University of Michigan Press, Ann Arbor, Michigan, 1933.

In an intensive short course, reviews must be frequent to insure the rentention of facts which have seemed casual in the learning. The very simplicity of certain devices assures their popularity with either the youngest or the oldest of the group. One device, frequently used and repeatedly asked for by the group, has no name other than "points". The group may be divided if there is a competent assistant, or if the group is too large for one single file where all may see the object of the quiz. Pass out to each one an equal number, say five, of one-half inch cardboard squares. The leader may point to a tree, call attention to a bird, or a movement in the grass, all previously discovered elsewhere, for one student at a time to answer. After the first one in line has had a reasonable chance to reply, if he is correct he is given a card; if he tries and fails, he gives up a card; if he does not try, it is "a miss". In any case he moves to the end of the line, and the next one gets a chance. Of course there are any number of variations which may develop in the playing. Later the cards are collected and the points for the game recorded.

Since the course must be accredited, it is not possible to be wholly without some form of ratings, but they are definitely in the background. The aim of the course is to succeed in getting each student to do his best to learn with wholehearted enthusiasm.

Attendance is good. The one worst cause of absences is poison ivy, no matter how careful and repeated warnings have been. Since each hour is equivalent to one day in the regular school year, it is essential to help the student to "catch-up", perhaps with some extra out-of-class field trip assignments, or readings and reports for the benefit of the group, or some supervised Saturday study. Another Saturday is used to replace the Fourth of July which usually falls within the six weeks period.

There is rarely any evidence of loafing, or "playing on the job". The difference between a "picnic" and a "field trip" is made quite plain in the learning of out-of-door manners. The greatest danger, to class and instructor alike, is to be startled into awareness after about three weeks. The "year" is half over, and the work yet outlined to be accomplished in order to stand the test of being "equivalent to one year of science" is still far from half done! Classroom days are limited as much as possible to rainy weather, or to meet the need of time for reference work or writing up notes in printable form. Too much of this work must not be left to do at the last. The young student does not take to the concentrated course as well as the older one. The fine spirit already engendered must not be lost under high tension "to make the dead line".

It has become the custom to have a watermelon feast when the last days are in sight. The parents of the present class, and the students and sometimes the parents of previous classes, are invited. In this manner a loosely organized "Alumni Association" has been growing from year to year. Some clever form of initiation of

the new members and a brisk election of Chairman and Recorder takes place. When it gets dark out of doors (we have only been rained in once), the screen is set up and Kodachromes are shown of many forms of wild life. It has been our good fortune to have a conservation-minded botany professor and his equally able, artistic wife to give a talk as a culminating feature of the field course each year.

Thus we have been able to draw together the home and community in a short period of six weeks of purposeful use of leisure time. Who is there to doubt that the uncatalogued results may be more far-reaching than those which are recorded in the certificates mailed to the students and schools concerned at the end of the summer! ●

The Smithsonian Institution

(Continued from Page 19)

the title "Smithsonian World Weather Records," compiled by H. H. Clayton.

The Annual Report of the Institution includes a General Appendix containing selected articles and reports on advances in the natural and physical sciences, written by competent authorities in non-technical language for the benefit of the general reader interested in keeping abreast of science progress.

The Bulletins of the National Museum are intended to contain the larger monographic studies on the national collections in biology, geology, anthropology, engineering and industries, and American history. The Museum Proceedings contain the shorter papers resulting from the researches of the staff and others on the Museum collections, notably the descriptions of thousands of new species discovered in the course of these investigations.

The Bureau of American Ethnology has published 48 Reports and 143 Bulletins, which together constitute a very substantial body of information on the anthropology of the Indians. Many of them, although published many years ago, remain the classic sources in the fields they cover. Other series issued less frequently, the titles of which are self-explanatory, are the Annals of the Astrophysical Observatory, the Oriental Studies and the Occasional Papers of the Freer Gallery of Art, and the Catalogs of the National Collection of Fine Arts.

All publications of the Institution are distributed free to some 1,500 libraries and scientific and educational institutions, insuring their availability to all who need them. In all the several series, more than 7,500 individual titles have appeared under the Smithsonian imprint, representing a total of some 12,000,000 copies of Smithsonian publications.

Another outstanding Smithsonian means of diffusing knowledge has been the International Exchange Service, a bureau of the Institution that grew out of Professor Henry's plan to exchange Smithsonian publications for those of learned institutions abroad. In 1886, a number of nations agreed to set up official government agencies to handle the exchange of governmental, scientific, and literary publications, and the Smithsonian service was established as the official United States agency under the name of the International Exchange Service. In 1939, the last normal year before World War II, the Service handled 714,877 packages of such material, weighing a total of 719,694 pounds.

In Retrospect

In assessing the worth of the Smithsonian Institution's first one hundred years of operation, two principal questions arise: Have James Smithson's express wishes been faithfully carried out?—and, to what extent has the Institution's work benefited the people of America and of the whole world?

To answer the first of these questions, we have reviewed very briefly Smithsonian activities in the increase and diffusion of knowledge. We have seen that the Institution has conducted and supported original scientific investigations in many fields that have added a very large amount of new knowledge to the previously existing stock; it has explored the whole earth in the interests of a fuller knowledge of our planet and of its inhabitants, human and animal; it has greatly expanded man's understanding of the sun, that star on which all life on earth depends; it has produced a whole body of new knowledge concerning the American Indians and other aboriginal peoples; and it has made all this new knowledge freely available to all mankind through its publications, through its International Exchange Service, through its million-volume library, through museum and art gallery exhibits, and through a world-wide correspondence.

The second question, concerning the value to mankind of Smithsonian work, is not so easily answered. Such values are not readily assessable, for cultural benefits are largely intangible. Yet the benefits are just as real as more material advantages—in fact, are of far greater importance with relation to the mental and spiritual aspects of man's development, through which alone he can hope to achieve his higher destiny. Without the great advances in knowledge brought about in recent centuries through the agency of such organizations as the Smithsonian Institution, civilized man would still live in superstitious fear of nature, and his advancement would still be blocked by blind ignorance and dogma. On the other side of the picture, the Smithsonian has had a very real part in the great upsurge of scientific progress of the last century which has resulted in so many economic applications for the direct benefit of mankind. So on both the cultural and material levels, the Institution has measurably served the human race. ●

★ ★ ★ ★ ★

Synthetic Liquid Fuels

(Continued from Page 10)

Station property at Bruceton, Pennsylvania, about 15 miles south of Pittsburgh. Six buildings, oil tanks, gas holders, coal bunkers, and other equipment will occupy a 12-acre area on the 160-acre property.

These buildings are nearly completed.

Detailed design, specification, and purchase are underway for equipment to install two 1-barrel-a-day gas-synthesis pilot plants, three experimental coal-hydrogenation pilot plants of about 10 gallons a day capacity, and laboratory-scale research apparatus for process development on both the coal-hydrogenation and gas-synthesis processes.

Larger pilot plants, possibly up to 10 barrels a day capacity, may be installed later if such larger pilot plants prove necessary for the design of the still larger (200 barrels per day) demonstration plants.

In order that no time should be lost while these new facilities were being designed and built, all available temporary laboratory space was provided in other buildings at Bruceton and at the Central Experiment Station of the Bureau of Mines in Pittsburgh, Pa. Approximately 150 scientists and assistants are now engaged in research.

Synthesis-Gas Production Division

Both hydrogen and carbon monoxide gases are used in making oil and gasoline from coal. The Synthesis-Gas Production Division is developing the most economical methods for producing these gases from coal and lignite. This work is being conducted at Morgantown, West Virginia, where the University of West Virginia, through a cooperative agreement with the Bureau of Mines, is providing laboratory and office space.

The work to be carried out by the Synthesis-Gas Production Division includes the preparation and testing of fuels and the design, installation, and operation of adequate gas-making, gas-purifying, and gas-handling equipment. Through the use of existing information and by means of laboratory and pilot plant scale research, it is expected that finished gas can be made at lower than present cost.

Demonstration-Plant Division

The purpose of the work in the Demonstration Plant Division is to carry the processes for the production of oil and gasoline from coal toward commercial utilization.

Before the plant site was selected, an extended study was made which included a survey of 206 proposed locations in 21 coal-producing states. After the end of the war it became apparent, however, that some of the government-owned synthetic ammonia plants used in the production of munitions would be closed, and that they would offer an ideal location for the demonstration-plant work. The War Department, acting through the Quartermaster General, has made the synthetic ammonia plant at Louisiana, Missouri, available to the Bureau of Mines. The Quartermaster General has a direct interest in the results of the Bureau's studies because he is responsible for the development and procurement of natural and synthetic fuels and lubricants essential to national defense. The acquisition of the plant will result in a material saving in construction costs and will greatly speed the demonstration-plant program. General facilities, such as offices, laboratories, boiler and power plant, water- and sewage-disposal systems, machine shop, railroad spurs, coal handling and storage facilities, roads and parking lots, and a cafeteria are available for immediate use. In addition, specialized equipment, such as gas-cracking units, gas purifiers, compressors, and circulators, will be incorporated as part of the demonstration plant.

Preliminary flow diagrams and plot plans are now being prepared for the erection of the coal-hydrogenation plant at Louisiana, Missouri. Initial design is based on about 200 barrels of oil per day. This may be modified materially, either on the basis of the size needed to give the desired engineering and economic results, or on the basis of the funds available for this demonstration plant.

Oil-Shale Divisions

The field activities of the oil-shale divisions are divided between the Petroleum and Oil-Shale Experiment Station at Laramie, Wyoming, and the Oil-Shale Demonstration Plant at Rifle, Colorado. Research and development work will be conducted in a new building now under construction on Bureau of Mines property at Laramie. A site has been selected and construction started on a demonstration plant to be operated at Rifle on Naval Oil-Shale Reserve No. 1 to mine and process about 200 tons of oil-shale a day.

Although many processes have been proposed for the recovery and refining of oil from oil-shale, as revealed by nearly a thousand patents, in the United States none have been successful as commercial ventures and few have been found to operate with caking shales. Shale oil has long been considered a substitute for petroleum.

SITE OF THE BUREAU OF MINES PLANT for Demonstrating the Production of Oil from Oil-Shale at Rifle, Colorado.

However, special methods of extraction and refining must be devised through research to develop products that will be suitable for use along with those of petroleum. The main function of the research and development laboratory, therefore, will be to conduct several types of studies correlated to provide a thorough insight into the physical character and chemical composition of oil shales from different states and the shale-oil derived therefrom, and to determine the proper conditions for processing these materials and their products and by-products to yield marketable commodities as economically as possible.

Petroleum is obtained as an organic liquid from holes drilled through the earth's surface to saturated oil-bearing sands. Oil-shale contains organic matter, but it is solid and the only means found so far for converting this solid material to a liquid is some form of heat.

Oil-Shale Mining

Offhand, it would seem that methods developed for coal and other minerals would be applicable to mining oil-shale, but oil-shale is not like coal. It is tough and, to a certain extent, elastic. The toughness of oil-shale becomes most apparent in the crushing to suitable sizes for handling and processing. Therefore, an investigation on the mining of oil-shale is an important part of the research and development program and will comprise a broad study of methods, equipment, and costs for large-scale mining of oil-shales of various characteristics under a wide variety of conditions. This work will include the collection and analysis of data from commercial mines of various types, as well as from the mine at the oil-shale plant.

At Rifle, Colorado, an oil-shale mine has been opened and the haulage tunnel driven 275 feet. This mine will provide 100 to 150 tons of shale a day for the retorts. An important part of the mining operation will be to develop low-cost methods of mining oil-shale and to estimate the costs of mining on a large scale.

Cost of Synthetic Liquid Fuels

In view of the relatively low conversion cost, cheap natural gas undoubtedly will be the first raw material to be used commercially for the production of synthetic liquid fuels in this country. Arrangements have been completed for constructing such a plant near Brownsville, Tex., where large reserves of natural gas are available. This plant is planned for a capacity of 6,000 to 7,000 barrels a day of primary hydrocarbon products, and it has been stated that the cost of the resulting gasoline and Diesel fuel will be competitive with production costs of these products from petroleum. With natural gas costing not more than 5 cents per 1,000 cu. ft., engineers of American petroleum companies have estimated the cost of producing gasoline from natural gas at figures ranging from 5 to 9 cents a gallon.

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Recent estimates tend toward the lower figure. A second plant using natural gas as a raw material is to be built in Kansas, and no doubt other plants will follow as practical experience is gained in these two plants.

However, the total reserves of natural gas will not be sufficient to take care of the increasing demands of the more distant future. For this purpose the much larger reserves of coal must be used, and that is the reason for the extensive Bureau of Mines program on the production of oil from coal. The large reserves of high-oxygen, poorly coking coals of Ohio, Indiana, western Kentucky, and Illinois, and those high-volatile bituminous coals not excessively high in ash or sulfur west of the Mississippi River, are available and potentially suitable for the production of liquid fuels by the hydrogenation process.

The subbituminous coals of Wyoming, Colorado, and Montana and the lignites of the Dakotas, Montana, and Texas are readily liquefied, and, from the point of view of wise utilization of mineral resources, constitute appropriate raw materials for synthetic liquid fuels. Conversion of these coals to liquids would solve storage and transportation problems. In the assay work conducted in the Bureau of Mines laboratories thus far, liquefaction proceeds most readily in coals of more recent geological age than Carboniferous.

The gas-synthesis or Fischer-Tropsch process has a much wider application to more diverse raw materials than does the hydrogenation process. Almost any carbonaceous material can be reacted with steam to produce carbon monoxide and hydrogen, which in turn are reacted with each other in their conversion to liquid hydrocarbons. Raw materials that have been used for this purpose include anthracite, all ranks of bituminous coal, coke, lignite, coal gas, natural gas, charcoal, wood and other vegetable matter. The German plants used coke from bituminous coal in the Ruhr district and brown-coal briquets or brown-coal char in central Germany. With considerably higher petroleum prices, it will be economically possible to produce gasoline and Diesel fuels by the Fischer-Tropsch process from solid fuels.

In the Appalachian region, the necessary synthesis gas can be produced from the lower grades of anthracite that do not find a ready market at the present time, and from high-volatile bituminous coals unsuitable for metallurgical coke. The Interior Province on both sides of the Mississippi River, with its very large reserve of poorly coking coals and its large population, is in a favorable position for the development of a synthetic-liquid-fuel industry. However, the largest reserves of solid fuels that seem to have the most promise for future conversion to liquid fuels are the lignite and subbituminous coals of the Dakotas, Texas, and Western Great Plains states. North Dakota alone has a reserve of 600 billion tons of lignite, and Wyoming has 590 billion tons of subbituminous coal. Some of these coals occur in very thick (20- to 50-foot) beds, and in one operation in Wyoming a total thickness of 80 feet is mined in an open strip pit. Strip mining under such conditions is very inexpensive.

Although much information has been obtained by the American technical oil mission to Germany, the data on costs require much more detailed examination than has yet been accomplished. The cost estimates from Germany very greatly in different plants and reflect hasty development and construction to meet war needs. From these reports thus far examined and from British and American industry estimates, it appears that, in general, the cost of producing gasoline from solid fuels in this country by the hydrogenation process would be about 10 to 15 cents a gallon more than the cost of production from petroleum; with future improvements in the Fischer-Tropsch process that are likely to develop as a result of research, it is regarded as quite possible that gasoline and Diesel fuel will ultimately be produced at a cost of only 6 to 8 cents more than the present cost of production from petroleum. Some authorities believe that this cost will be less than that of mining and processing oil shale. The Bureau of Mines, in its synthetic-liquid-fuel program, is making no assumptions on costs at present, but is including oil shale and both synthetic-fuels processes in its experimental investigation on methods and costs. ●

Becoming a Scientist

(Continued from Page 2)

in learning about the work done by Dr. Jordan. Any interested student may find abundant material for class and club reports of the work accomplished by this truly great American biologist. ●

BOOKS BY AND ABOUT DAVID STARR JORDAN

These brief lists were prepared by Margaret Eleanor McCann, Librarian, Duquesne University.

Brown, Charles Reynolds. *They Were Giants.* Macmillan. 1935. pp. 179-210.

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Jordan, David Starr. *Guide to the Study of Fishes.* 2v. Holt. 1905.

BOOKS TO AROUSE INTEREST IN THE CAREER OF A NATURALIST

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Sharp, Dallas Lore. *A Watcher in the Woods.* Century. 1903.

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for MARCH, 1947

NEW BOOKS

The Ancient Maya

• *By* SYLVANUS GRISWOLD MORLEY, Stanford University, California. Stanford University Press, 1946. Pp. XXXII + 520. $10.00.

I enjoyed this book. It is an interesting and scholarly contribution to recent anthropological studies; but it can be read with interest and profit by those who have a limited knowledge of and interest in anthropology.

The first chapters describe the present-day country and people. Then successively are treated the early days of the Maya civilization, the Spanish conquest, and the agriculture, religion, government, art and intellectual achievements of the people. According to Dr. Morley "In the fold of abstract mental achievements the Maya had no equals anywhere in ancient America. . . . They were the inventors of writing in the New World." In astronomy they were far ahead of every other people of America and even surpassed the Egyptian. "They developed man's first positional arithmetical system, one involving the concept of zero."

While manifesting a profound and even affectionate respect for the Maya people, in the study of whose culture and civilization he has spent many years, Dr. Morley gives an objective appraisal allowing the discovered facts to speak for themselves. He has admirably avoided any imaginative interpretation of the facts, or a personal re-creation of a history.

This beautifully illustrated book is another proof that a work can be scholarly and still have popular appeal. It should receive a warm welcome from specialist and layman alike. My fear is that this book into which has gone so much learning may not receive the wide attention it deserves.

Very Rev. Francis P. Smith C.S.Sp.
President, Duquesne University.

What Industry Owes to Chemical Science

• A Symposium. Chemical Publishing Co. Inc.: Brooklyn, N. Y. 1946. First American Edition. Pp. VIII + 372. $5.00.

This book will increase the reader's understanding of the often unobstrusive part chemistry plays in everyday life, and his respect for the role of the chemist in industrial and social development. It should aid the student of chemistry in selecting a field of specialization. It offers valuable information to the student who is considering chemistry as a life work. The general reader of non-scientific background will enjoy it since it is written in simple, non-technical language.

Fifty-three British scientists cooperated in preparing brief but informative accounts of the chemist's work in dozens of fields including, among others, foods, soaps, dyestuffs, textiles, paper, pharmaceuticals, plastics, building materials, rubber, paints, and explosives. Brief bibliographies accompany each chapter. There is an introduction by Alexander Findlay, President of the Royal Institute of Chemistry.

H.C.M.

Chemistry for Our Times

• *By* ELBERT COOK WEAVER and LAWRENCE STANDLEY FOSTER. New York: McGraw Hill Book Company. 1947. Pp. XII + 738. $2.48.

This well-written, attractive book provides a challenge to high school pupil and teacher alike. It should appeal to both. It is not easy; neither is it too difficult. New developments in theory and practice have not been omitted. Its approach is practical, and a commendable balance between principles and applications has been maintained. Stimulating previews open each unit and each chapter. Numerous questions are interspersed throughout the text. Other "challenging questions" and a summary close each of the forty chapters. Teachers will appreciate the postponement of chemical calculations until late in the course (Chapter XXIV).

The format catches the eye, the type faces are well chosen, the photographic cuts and line drawings well done. We believe the authors have succeeded in their aim to teach the student to understand his environment, the method of science, and the applications of chemistry to the life activities of the average citizen.

H.C.M.

Scientific Instruments

• *Edited by* HERBERT J. COOPER. Brooklyn, N. Y.: Chemical Publishing Co. 1946. Pp. 305. $6.00.

Have you ever wondered how a gyropilot works? A hardness tester? A cathode ray tube? This book supplies the answers in a comprehensible but not superficial way.

The material is divided into five sections: Optical Instruments, Measuring Instruments, Navigational and Measuring Instruments, Liquid Testing, and Miscellaneous (Acoustics, Calculating Machines, etc.). All standard instruments in these classes are described in principle, construction, and operation.

High school or college students with scientific or mechanical inclinations can read this book with enjoyment and profit. They must not, however, be surprised or discouraged if they find some sections rather hard going. Teachers, especially of physics and general science, will find a great deal of information to broaden their background and to enliven their discussion of various parts of their subjects.

T.H.D.

Competence in Mathematics

(Continued from Page 6)

and where we want to go, and why we are doing what we do."(3)

And regarding the anarchy prevailing in the field of objectives, we are told on good authority that "more than 1,500 social aims of the study of English, more than 300 aims of arithmetic in the first six grades, and more than 800 generalized aims in the social studies have been listed" in reports on current courses of study.(4)

In the face of this situation it would seem to be absolutely futile to add still another document to the "literature" on educational objectives. Its only possible excuse must be found in the desire to reduce, however slightly, the extent of our uncertainty.

Fighting Our Way Out of Confusion. A pilot who has lost his way will try, at any cost, to return to his "true course." In like manner, the battle of objectives to which we have referred must be brought under control if we wish to get anywhere in education. Moreover, today the eyes of the world, as never before, are on the United States. We cannot occupy a position of trusted leadership in world affairs, particularly in connection with the immensely important organization known as UNESCO, if we ourselves are drifting.

Let us consider some of the steps that may lead us out of the present educational jungle.

It should be realized, of course, that our conflicting philosophies and psychologies, and our divergent social, economic, and political theories cannot be harmonized by any fiat decree whatsoever. Recent world events have amply demonstrated that. Thus, a pragmatist flatly refuses to become an idealist. Again, a crassly utilitarian outlook has only contempt for such "outmoded" concepts as "culture," "discipline," "appreciation," and the like.

This being the case, it is proposed that we approach our problem with the same scrupulous honesty and objectivity that we commonly expect to find in the work of a modern research scientist. Purely subjective opinions and beliefs must then yield place to the impartial verdict of "facts". If this is accepted as a point of departure, we are soon led to considerations such as the following:

First, education has gone on long enough to warrant certain inferences on the basis of *experience*. Pragmatism asserts that a necessary test of an idea or a process is that it shall "work". By a sort of *negative* pragmatism it follows that a plan or a program which does *not* work in the classroom of the average teacher cannot be regarded as satisfactory and must be discarded. This pragmatic test alone would surely eliminate many vexing issues and help to restore sanity.

Second, a scientific worker will not entertain *contradictory* hypotheses or inconsistent practices. Consistency is certainly one of the basic tenets of mathematics. Why not use it in the field of education? We should then be in a position to get rid at once of some of our worst trouble zones. Thus, it is inconsistent to glorify "individual needs and interests" and at the same time to demand "results" on the basis of standardized tests reflecting rigid curricula. Nor should should one expect "functional competence" when there is automatic promotion, irrespective of attainments, or when teaching schedules are regularly set aside in favor of all sorts of extracurricular diversions.(5)

Third, a new scientific theory is not generally accepted until it has been definitely validated by juries of able scientists working in recognized research laboratories. Science has become a coöperative affair. What an immense amount of collective effort has already been devoted to such new domains as that of atomic energy, of radar, of aeronautics! Industrial research in the United States has assumed the proportions of a major industry, as Dr. C. E. K. Mees informs us. In 1940, more than 2200 laboratories were engaged in industrial research, with a personnel of over 70,000. The annual budget of these laboratories is now estimated at half a billion dollars.(6)

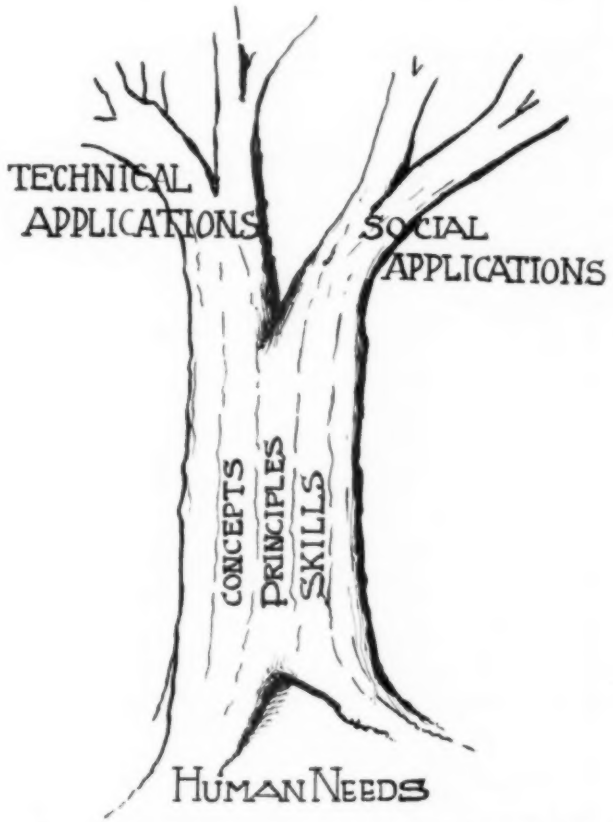
Is it not evident that education likewise has become too complicated to depend so largely on the uncoördinated efforts of individual teachers or on unrelated committee reports? To be sure, teaching is primarily an art. But the average teacher, even at best, must be regarded as a "general practitioner". In isolation, he cannot possibly cope with a multitude of problems that require constant attention in this age of mass education, problems of content and method, of organization, time allotment, grade placement and standards, not to mention differentiation, integration, and the like. To deal more effectively with these problems, we need numerous coöperating laboratory schools, with a nation-wide program of research, and these schools should be manned by a carefully trained corps of master teachers. Only then can we hope to cast off the intolerable burden of mere guesses or vapory assertions that vitiate so much of our educational literature.

To sum up, it is proposed that we attack the prevailing educational confusion at its root by using as sharp pruning knives the verdicts of classroom experience, the canons of clear thinkiing, and the techniques of coöperative research, instead of relying so helplessly on the unsupported opinions of theorists who "know all the answers", usually at a safe distance from the classroom.(7)

II. Three Basic Components of Functional Competence

Mathematics as a Tree of Knowledge. A famous mural by John Norton, entitled the "Tree of Knowledge", attracted much attention at the Century of Progress Exposition in Chicago. The roots of this allegorical "tree" represented the *basic* sciences and its branches typified the *applied* sciences. At the foot of the tree, forming its very foundation and main root, was placed the legend *Mathematics*.

We shall find it helpful, in this discussion, to view mathematics itself as a tree of knowledge. It will be seen that the roots, the trunk, and the branches of this tree suggest important lessons as to the nature and the organization of a "functional" program in mathematics.



The Story of the Tree. Mathematics is the oldest of all the sciences. This is not an accident. It grew out of the most fundamental human needs, those centering around *food*, *shelter*, and *clothing*. It was these needs that caused people to *count* and to *measure*, and to develop the *practical arts* which prepared the way for modern science and technology. From these crude beginnings, and rooted in a strictly utilitarian soil, there issued in the course of many centuries the majestic tree of mathematics. It has never stopped growing. In fact, today its growth it far more vigorous than ever. Let it be stressed that this tree is the product of the ages and the common property of all mankind. And what made it grow? Like every other tree, it drew its strength from the soil and from the mysterious chemistry of the foliage on its many branches. Human needs have been the permanent soil of the tree, and all manner of technical and social problems have been responsible for its branches. But what about the trunk of the tree, the "common carrier" of all its branches? It is made up of an ever increasing body of concepts, principles, and skills, the very core and marrow of the tree.

This allegory is as important as it is true. It is introduced here to make clear the central thesis of this paper. This thesis is to the effect that we cannot have branches without a trunk, nor can a trunk survive without flourishing branches. We shall now proceed to examine this fairly obvious truth in relation to the debated problem of functional competence in mathematics.

The Trunk of the Tree—a "System of Ideas". Today we know that it took a very long time to produce the present framework of mathematics. Only by slow degrees, step by step, did mathematics develop its ingenious number system, its techniques of computation and of measurement, its imposing body of geometric facts and relations, its algebraic symbolism, and its modes of solving problems. Together, these categories helped to form the trunk of our mathematics "tree."

Now, the most characteristic aspect of this impressive assemblage of concepts, principles, facts, and skills, is the organic, almost biological interrelation of its parts. Mathematics is, to a very large extent, a *cumulative* body of knowledge. Thus, one must master the addition facts before going on to multiplication. One must understand fractions and decimals before attempting to deal with percentage. Algebra presupposes proficiency in arithmetic. There is a similar hierachy in the field of geometry. In all stages, the road is from very simple, almost self-evident "first principles" to the more complex areas.

This is the meaning of the time-honored dictum that in mathematics there is "no royal road to learning." All attempts to evade the highly sequential organization of mathematics have regularly failed. That is, we cannot have a "hit-or-miss" approach in mathematics, no "incidental" or "get-rich-quick" procedures.

. Hence the very first lesson which should be borne in mind by those professing to be interested in functional competence in mathematics is the fact that mathematics is a *system* of ideas. This system is quite independent of the pupil's "felt needs and interests." No one has stated this issue more forcibly, in recent years, than Professor Harry G. Wheat of West Virginia University. In the following significant quotation, due to his pen, the word "arithmetic" has been replaced by the broader term "mathematics." This passage then reads as follows:

> "*Mathematics is a system of ideas.* It is not a collection of objects. It is not a set of signs. It is not a series of physical activities. Mathematics is a system of ideas. Being ideas, mathematics exists and grows only in the mind. It does not flourish in the world of things. It does not arise out of sensory impressions. It has nothing to do with the amount of chalk dust forty pupils can raise in a schoolroom in thirty minutes. Mathematics exists and grows only in the mind. Being a system, mathematics must be taught as a system. *It is not an outgrowth of the individual's everyday experiences. It is not learned according as the interests or the whims of pupils may suggest.* It is not anyone's personal discovery or invention. *Mathematics must be taught as a system.*"(8)

It seems fairly clear, then that *the first component of functional competence in mathematics is the systematic study, within a desired range, of the underlying mathematical concepts, principles, and skills.*

All this sounds quite convincing and "as it should be",—to the mathematician. Sooner or later, however, doubting Thomases will insist on raising the same old haunting questions:

"*How much* of this 'system' are you going to prescribe for the average learner and for the slow learner?"

"What is the '*practical use*' of mastering this 'system'?"

"How do you propose to *teach* this 'system'?"

In other words, we have not reached the end of our search. We are expected to point out further, more appealing components of functional competence.

Well, at this embarrassing point we recall with relief that our mathematical tree possesses, not merely its very substantial trunk, but also an abundance of life-giving branches.

The Branches of the Tree—"Life Problems". The close connection between mathematics and "life situations" is not exactly a recent discovery. Instead, it has a rather antique background. The oldest mathematical papyrus, that of the Egyptian scribe Ahmes, dating back to about 1700 B.C., is merely a compilation of decidedly homespun problems and their solution. In ancient Babylonia, as we are learning from many clay tablets now preserved in the world's museums, business transactions having to do with sales, loans with interest, mortgages, and the like, were of common occurence. Greek, Roman, and medieval records tell a similar story. Human needs, as was pointed out above, represent the very root of the mathematical tree, while a host of related "life problems" caused the tree to grow and to flourish.

This vital connection between mathematics and human affairs cannot be ignored without disastrous consequences. So far as the school is concerned, whenever mathematics is "out of step with Life", the subject soon degenerates into a domain of "inert ideas". None other than Professor Alfred N. Whitehead, the distinguished mathematician and philosopher, has furnished the most compact warning against this danger. To quote,

> "There is only *one* subject-matter for education, and that is *Life* in all its manifestations. Instead of this single unity, we offer children—Algebra, from which nothing follows; Geometry, from which nothing follows; Science, from which nothing follows: History, from which nothing follows; a couple of Languages, never mastered . . . Can such a list be said to represent Life, as it is known in the midst of the living of it?"(9)

In this highly practical and utilitarian age, the educational danger of "inert ideas" is being reduced to a minimum. Few school people today would disagree with the spirit of Professor Whitehead's remarks. And so, we may safely assert that *the second component of functional competence in mathematics is a proper emphasis on the significant interrelations between mathematical theory and its many-sided applications.*

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Having said all this, however, we must at once raise our voice against a pathological distortion of the doctrine of "life situations". We find this distortion in many recent pronouncements, particularly in discussions pertaining to "felt needs and interests", "the experience curriculum", "social utility", "minimum essentials", and the like. It reaches its acme in the bold demand that the "new" program in mathematics, for "the other 85%" be dissociated from "the organized body of the science of mathematics", and be derived from "an analysis of the life situations and experiences that students will likely have during and after their school training".

The fallacies underlying such a program have often been pointed out, but without apparent success. The prospect of getting the fruit of the tree without bothering about the tree itself seems to be too alluring to many educators. Nevertheless, let it be stated again that all attempts to build a mathematical program entirely on the basis of "social utility", "life situations", or "practical problems"—and there have been very persistent attempts of this sort—have always failed completely. A record of these failures is readily accessible.[10] And the reason for these failures can be stated in a single sentence: *"Mathematics is a system of ideas, and must be taught as a system", but no one has ever succeeded in organizing the more or less accidental "experiences" of thirty or more pupils into a system co-extensive with that of mathematics.*

The Mathematical Tree and the School. Whether mathematics is viewed as a system of ideas or as a correlated body of significant applications, it corresponds to *an objective reality independent of the learner.* It remains to consider the *subjective* relation of the pupil to this area of learning. For, as one educator correctly expresses it, "to formulate a program of essentials is only part of the problem. We must also determine to what extent and which students can master the essentials, as well as to apply a follow-up evaluation to ascertain if the essentials once learned actually become functional. This is a big order but nevertheless necessary".

That the acuteness of this problem is being felt may be inferred from the ever growing literature on such categories as motivation, meaning, orientation, appreciation, evaluation, and transfer. Many new and valuable chapters have been written on the learning process. The doctrines of generalization and of transfer, as formulated especially by Professor Judd, are at last coming into their own. In the field of mathematics, a central maxim due to Professor Dewey is beginning to receive the attention it deserves. It reads as follows:

"Practical skill, modes of effective technique, can be intelligently, non-mechanically *used*, only when intelligence has played a part in their *acquisition*".[11]

Perhaps we are ready, then, for the acceptance of still another component of functional competence in mathematics. This *third* component, the *subjective* factor, may be formulated as follows:

. Functional competence in mathematics is largely the outgrowth of a continuous and painstaking emphasis on the categories of understanding, mastery, and transfer.

To sum up, we have pointed out three basic components of functional competence in mathematics. We have seen that mathematics may be viewed as an objective *system of ideas*, as an objective *body of related applications*, and as a subjective *area of learning*. It is the composite thesis of this paper that only a proper regard for *all three* of these components will enable us to build a truly functional program in mathematics. ●

(The second part of this paper, entitled "Elements of a Functional Program in Mathematics", will appear in our June number.)

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Rubber

(Continued from Page 13)

when exposed to sunlight, air, heat and flexing. Use of organic accelerators had lengthened the life of many products, but scientists felt it vital to control aging by other methods than vulcanization. The first major contribution in this field was by Dr. W. C. Geer and W. W. Evans who devised in 1920 an oven method for the accelerated aging of rubber. Under regulated conditions this approximates within a few days the result of years of natural aging, and enables scientists to measure the deterioration rapidly. Harold Gray and H. A. Winkelman four years later created chemicals which prolong the life of rubber when incorporated in the compounds. Many other chemical combinations have since been used.

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(To be continued)

"Science must be free. Wherever it is controlled, it has been only partially productive. In an unsympathetic atmosphere science withers and dies, and all mankind is the loser."

C. F. KETTERING
Science, Dec. 27, 1946.

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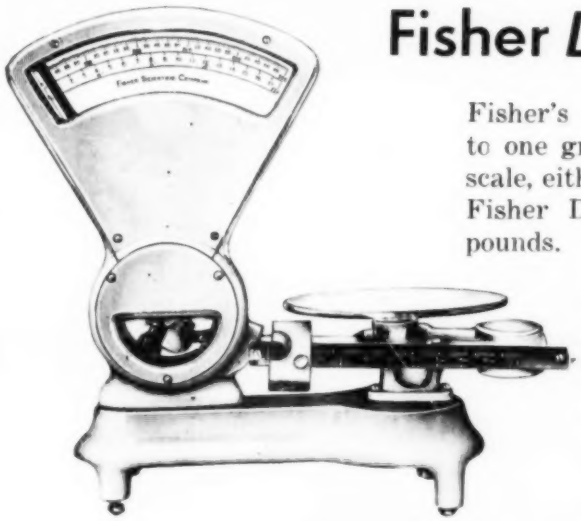

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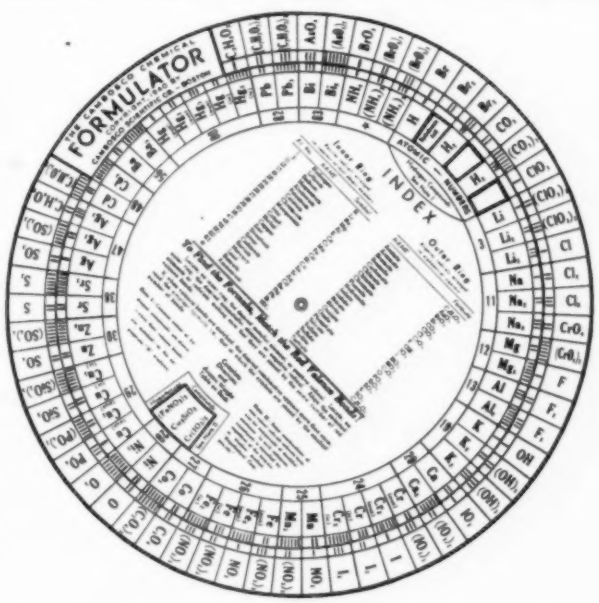

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